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NASA SP-37

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CONFERENCE ON SPACE, SCIENCE, AND URBAN LIFE

DUNSMUIR HOUSE, OAKLAND, CALIFORNIA • MARCH 28-30, 1963

The Dunsmuir House Conference was supported by the National Aeronautics and Space Administration and The Ford Foundation in cooperation with the University of California and the City of Oakland

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONFERENCE ON

SPACE, SCIENCE, AND URBAN LIFE

DUNSMUIR HOUSE, OAKLAND, CALIFORNIA, SITE OF
THE "CONFERENCE ON SPACE, SCIENCE, AND URBAN LIFE"

Dunsmuir House is a mansion located in a 70-acre garden setting in the City of Oakland. Built in 1890, it was recently acquired by the city as a center for educational, business, and governmental conferences and seminars concerned with economic and environmental problems of urban communities. A nonprofit corporation administers Dunsmuir House and its parkland estate, with the active support of the Mayor and the City Manager of Oakland. Several professional research and development sites have been established in the "Peralta Oaks" area surrounding the garden. The "Space, Science, and Urban Life Conference" was the first national event held in Dunsmuir House.

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Proceedings of a conference held at Oakland, California, March 28-30, 1963, supported by The Ford Foundation and the National Aeronautics and Space Administration in cooperation with the University of California and the City of Oakland

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FOREWORD

Can a national program of space exploration be applicable to the daily tasks of the men and women who live and work in our central cities? How may new knowledge, developing in these days of scientific and technological revolution, be used to seek answers to the critical issues facing expanding urban populations?

These were but two of the many questions that initiated a discussion by 35 men in June 1962. Called together by Oakland City Manager Wayne Thompson, they gathered for a conference in Dunsmuir House. The businessmen, educators, scientists, and governmental officials of that group had a conviction that many of the techniques necessary to launch and sustain man in outer space could be applied to the environmental conditions of man within his earthbound community. There were no delusions that the transfer of scientific data from the laboratory to the problems of urban life was an easy process. Few would deny, however, that the explosive growth of population and the complexity of metropolitan society demanded that serious consideration be given to this potential. The "Conference on Space, Science, and Urban Life" that materialized nearly 9 months later was the first major step.

The generalized concepts from the June discussions were reduced to a set of purposes and objectives:

- *to bring together leaders of industry, labor, universities, and governments to explore techniques for translating basic research findings and new technology of the space age into practical programs to solve problems of rapidly expanding metropolitan areas.*
- *to consider and evaluate the application and relevance of new technology to the needs of industry and cities for new processes, products, materials, and techniques which will enhance and stimulate the productive economy and industrial growth of the city, state, and nation.*
- *to analyze the political, sociological, physical, and economic impact of the massive space and scientific research and development programs upon our urban and industrial communities.*
- *to establish a continuing program to utilize the collective resources of government, education, industry, and research to solve municipal and regional problems and to seek the other goals noted above.*

It was recognized from the outset that the greatest contributions from the first conference on this theme would come from defining the areas that provide chances for early use of new knowledge from scientific and space technology. Other meetings would be necessary to study in depth the ramifications of each topical inquiry. Although numerous specific programs and applications were suggested at the "Conference on Space, Science, and Urban Life," the most lasting benefits to society may well derive from the continuing efforts of a permanent citizens' committee established by City Manager Thompson to evaluate the conference findings and initiate experimental programs in Oakland and other communities in the San Francisco Bay Area. As a preliminary, a comprehensive summary and analysis of the conference was undertaken by the Stanford Research Institute. The summary is included in this publication. From the SRI evaluation has emerged a statement of programs that will serve as an initial guide to experimental projects applying new technology in the quest to improve the urban and economic life of all peoples.

The city of Oakland and the University of California are indebted to NASA and to the Ford Foundation for the financial support and encouragement that made the Dunsmuir House Conference possible. Appreciation should also be expressed for the interest and active participation of the Conference Sponsoring Committee: James E. Webb, Administrator of NASA; Dr. Clark Kerr, President of the University of California; George P. Miller, U.S. House of Representatives, Chairman of the House Committee on Science and Astronautics; and John C. Houlihan, Mayor of Oakland. Acknowledgment is also due the Conference Planning Committee, the Oakland City Manager and his staff, and the leaders of industry, education, business, labor, science, and government who attended the conference. Many of the delegates are acknowledged by their papers or statements published in these proceedings, but all participants contributed a personal dimension and insight to the subjects under discussion. Finally, we are especially indebted to Dr. Smith DeFrance, Director of NASA's Ames Research Center, and his staff members under the leadership of George G. Edwards, who collated the papers and seminar discussions for these proceedings. We hope that this publication will be a useful reference to the first efforts to relate "Space, Science, and Urban Life."

CLIFFORD L. DOCHTERMAN,
Oakland, California.

ORIENTATION SESSIONS

Chairman: C. EASTON ROTHWELL
President, Mills College

THE SPACE CITY, AND THE CONFERENCE OBJECTIVES

Wayne E. Thompson

WAYNE E. THOMPSON, City Manager, Oakland; President, International City Manager's Association; Consultant, Ford Foundation and Washington Center for Metropolitan Studies, Formerly: City Manager, Richmond, California. University of California (AB).

NEVER BEFORE IN HISTORY have city problems affected so many people in every conceivable way. Sixteen thousand people are moving to our cities every day. We now have 116 million people living in cities in this country. There are now 91,000 separate units of local government, and these cities alone are spending $16.5 billion each year. All our local governments now employ as many as 5 million public servants in this country. These same trends in other countries indicate that the world is attempting to become a city. When we realize that there are 3 billion people on the earth today, and in 35 years we will have 6 billion, we can appreciate the problems that lie ahead.

Lewis Mumford has said, "The building of cities remains man's greatest work of art, ranking with language itself." Our urban living areas, where most of our people live, should reflect the best in our technological advances. We all agree that they should not be reserved for the moon or for a war.

We are experiencing the greatest population explosion and migration to the cities in history and the problems are growing in direct proportion. We believe that now is the time to design the city of the future. Marvelous new things and wonders can transform our cities and our way of life.

It is imperative that we depart from timeworn traditions and concepts and adopt space-age techniques to cope with the problems of our space-age cities. For some years now, the preponderance of the Nation's scientific talent has been directed to solving problems of national defense and space research. It is our hope that we can direct a good proportion of this scientific information to solving our urban problems.

To provide the resources for continuing our space efforts, it is essential that this rapidly growing body of knowledge be applied to our industrial economy.

The purpose of this conference is to explore new ideas and to evaluate new applications of space research to the problems of a city and its business and industrial community.

We have represented at this conference the leaders in space technology and the urban specialists of the Nation. By bringing these two groups together we hope to set the course and develop the pattern for applying this scientific know-how to the problems of urban living.

Industry uses technology to reduce operating costs. This is our aim. We cannot meet the new and current problems of the urban areas without revolutionary changes in our present methods, which are now steering us on a collision course with bankruptcy. This is also causing us to default in our responsibilities in the critical areas of education, juvenile delinquency, and our other sociological problems.

To demonstrate how financially great these problems can be, consider that in this country alone in the next 10 years we will be spending $\$1/2$ billion for welfare costs alone. We who are close to the taxpayers are struck by the fact that many of our elderly people, who are at this time living on fixed pensions, meet their tax increase responsibilities each year by cutting down on the amount they spend for food and clothing.

Our central cities today are financially incapable of meeting our present problems without the adoption of bold new techniques. The exigencies of this age demand a change in emphasis in municipal responsibilities and activities to meet the needs of a changing society in this age of change. The problems are so great and so technical that government, private industry, and the universities must work in partnership to solve the problems of our urban areas. This is necessary if we are to restore balance and social and economic stability to these areas.

What does a city like Oakland require to keep its capital plant current with the needs of our space-age society? Consider that in the city of Oakland alone all levels of government are spending during this 10-year period three-quarters of a billion dollars for necessary public construction projects. This clearly illustrates the magnitude of the hardware and construction needs of a modern central city. This total does not include the cost of Oakland's new subway and rapid transit system which will soon be under construction. Our new municipal priorities make it mandatory that we find more economical ways of supplying capital plant needs.

The minority group problem, unemployment, crime, and educational problems are growing daily. This is why so many people are asking why we are going to the moon when we cannot find the answers to problems on earth.

In our Oakland Police Department, we are revolutionizing our methods and techniques. In addition to applying the probability theory to capture rapists, burglars, and car thieves, we can also use the computer to enable the traffic officer to get all the information about a driver before he stops him for a traffic violation. He will read the license number of the car he is following into the central police data bank, and the computer will within seconds return to him the name of the driver, whether he has a police record, where he lives, and so forth.

An illustrative case occurred here about a year ago, wherein a rapist-burglar would enter homes occupied by lone women, rape the woman, and rob the house. He had the whole community disturbed. We turned to space-age techniques, and we used Bromwich's probability theory. On a particular night, we had 25 police officers in a target neighborhood before the burglar got there, and the analyzer working the equipment became so interested in the case that he too went out and even picked the exact house. We were there ahead of the burglar.

To increase the police protection for our citizens, we are presently working on a telephone that will automatically dial the Police Department when a burglar enters a residence. On the same telephone, we hope to include a fire detection device that will automatically dial the Fire Department when a fire occurs.

Our new community research program is seeking to tap these vast reservoirs of new knowledge in order to accelerate development of our community. Scientific research must be made in such fields as telemetering, where there would be no electric wiring such as in housing; reading of meters by phone; the demolition of slum buildings by the use of controlled sound waves; and the relocation of displaced families by means of special type mobile temporary housing.

We will use computers to analyze the possibilities of fire in a given location under various conditions and to tell us how to prevent a fire in that area. We also foresee the development of expendable robot firemen that will appreciably reduce the hazards of firefighting.

We note, for example, that space research provides for waste disposal for astronauts. We believe these methods might be adapted to the needs of the city to eliminate costly and extensive sewage systems.

New communications systems will replace millions of wires and cables now required in large cities; and projects like Telstar and new jet and rocket travel developments will make close neighbors out of great metropolitan centers like Washington, D.C., and Oakland. New fuels and facilities can solve our highway and transit problems. New sources of solar energy will heat our homes, and nuclear energy will turn the wheels of industry.

James E. Webb, Administrator of the National Aeronautics and Space Administration, has stated that a corporation, or even a regional area, will remain effective and prosper in this new age "only through closest coordination between educational institutions and business and industry." He stated that progress and prosperity will hinge upon institutional scientists "feeding into the industrial stream the new knowledge which flows from a vast research and development effort."

One of the primary aims of this conference is to establish a Local Continuing Committee, composed of leaders of this area. The committee will represent a partnership composed of university, industrial, foundation, and government leaders who will implement the ideas produced at this conference. We believe the results of this partnership will strengthen the private sector and enable it to assume new functions and services in lieu of abdicating them to the already overburdened and overtaxed public sector.

The public sector will play a supporting role and take on additional functions only when the legislative bodies make formal findings that the private sector cannot perform the new services required.

It is our hope that the participants at this conference will be so successful in showing how to apply space science techniques and materials to the central city that it will provide a pattern which can be transmitted to urban areas around the globe.

The moon shot has a higher purpose—a more meaningful life for the individual in an automated society. We are confident that by stimulating our local economies by the introduction of new space-age industries we are going to bring jobs and payrolls to each community and substantially reduce unemployment so that the Gross National Product will keep pace with the growing needs of our economy.

Our financial abilities are incapable of meeting these problems without new techniques. We are hopeful that this conference can point the way to solutions of these critical urban problems.

NASA has indicated that Oakland can become the Nation's first space-age city, that it can be the laboratory for the Nation's scientists to implement the new ideas gained from our space effort. This city will be proud to test the ideas and imaginative proposals suggested by this conference and sponsored by our Local Continuing Committee.

It is impossible to predict accurately the marvels of the new space age and how it will affect our lives and those of our children. We do know that the opportunities for good living and an improved society are limitless.

IMPLICATIONS OF THE SPACE EFFORT FOR SCIENCE AND TECHNOLOGY

Dr. George L. Simpson, Jr.

DR. GEORGE L. SIMPSON, Jr., Assistant Administrator for Technology Utilization and Policy Planning, NASA. Formerly: Executive Director, Research Triangle Committee of North Carolina (University of North Carolina, Duke University, and North Carolina State University) to expand research activity in the South; Professor of Sociology, University of North Carolina; Consultant to Governor of North Carolina; Member, Institute for Research in Social Sciences, University of North Carolina; Member, National Public Advisory Committee on Area Development, U.S. Department of Commerce. University of North Carolina (AB, MA, PhD).

SCIENCE, when taken with its attendant technologies, is a broad and massive force that has, more than any other single force, remade our life in far less time than was required to explore and master this continent. Urban life, whose basic structure is the great city and its hinterland, is the way of life to which we have come in our lifetime. In this fast journey from country to city, we have necessarily left behind many of the values of family and community life that held our society together. We have had to abandon also many of the structures of public life and of economy that were formerly sufficient.

It has fallen in very large part upon our metropolitan centers not only to receive the people but the problems as well. The purpose of this conference is to find ways in which the space effort specifically, and science generally, can be brought to bear on those problems.

The National Aeronautics and Space Administration was created by the Space Act of 1958. To NASA was given the main job of creating and proving in an operational way a broad capability of going into space with large loads, of surviving there, of taking new knowledge of nature from the more unobstructed view of the universe thus achieved, and of helping to operate in space in every way required by the national interest. Space activities peculiar to the defense of the United States were left with the Department of Defense.

The decision to create a space capability was the product of the fact that our technology and that of the Russians had made it possible to leave the earth and enter space. It was a national decision—initially made under one Administration and reaffirmed by the present Administration. As a rough measure, it is fair to say that space budgets have been doubled every year through fiscal year 1963. A large increase of $2 billion in the NASA budget—to a total of $5.7 billion—is recommended for fiscal year 1964. In addition, something on the order of $1.7 billion has been recommended for other Federal agencies with auxiliary interests in space, bringing the grand total to approximately $7.4 billion. This intensification of effort rests on the fact that in achieving our space goals, as in all large and important undertakings, time is a critical factor. How fast we move is important to both our friends and our foes, and no one in a position of responsibility can ignore this consideration.

A rigorous schedule that reflects a sense of urgency and that calls for extraordinary commitments is required. Otherwise, indecision, slovenly work, and a council of fears will multiply delays at a cost not only in time, but in dollars, man-hours, scarce talent, and even in national safety. The space effort requires the mobilization in a free society of a great amount of pure scientific work, not only in the most advanced technologies, but in the creation of new technologies, including especially the devising of new systems of great delicacy and very high levels of reliability. These systems must operate millions of miles out in space in a harsh unfriendly environment.

The space effort requires the total range of talents and abilities and the commitment of American industry. It requires also the successful establishment, through democratic processes, of the public policies required to uphold such an enterprise. It is truly a total effort, unprecedented in peacetime.

The hard question is how to define a space program that will meet the basic national requirements without spending more than is essential of either money or talent. A typical decision in NASA is between the important and the essential, and certainly there is no single measure that distinguishes between these two choices. The decision to land men on the moon does contribute a part of the answer to this difficult question. Going to the moon is not only important in itself; the requirements of the journey provide, at the same time, a sharp focus for achieving a large part of the basic space capability that is NASA's first mission. The large boosters, together with the massive ground installations required, are the same facilities required to lift heavy loads for any other purpose—for example, for building manned space stations if these are needed. The ability to put men into space, to join one spacecraft with another, to sustain life for long periods, to communicate and to navigate—all these are transferable to whatever achievements in space the national interest may require.

The Mercury program of one-man flights leads into the Gemini two-man flights of longer duration. In Gemini many operations will be carried out that are required for the three-man Apollo flight to the moon. The large boosters being developed for the Apollo program, symbolized by the Saturn launch vehicles, are the ones that will overtake the Russians in lifting capacity, the area in which they now lead. The journey to the moon also provides some of the focus for our work in science—for instance, the study of radiation belts and of the nature and time of solar emanations. These and many other aspects of the space environment require continuous investigation in order to assure a safe passage.

The NASA science program, however, is necessarily broader than the moon journey. Perhaps the greatest prize of space will be simply knowledge, a deeper understanding of the nature of the universe. No one who has lived through recent decades can doubt the value of an advance in fundamental knowledge. For this reason all program decisions in NASA are measured against the adequacy of the science effort. The decision to sustain this effort is firm.

The responsibility for the scientific exploration of space rests with the Office of Space Sciences. Of equal interest is the work performed in the Office of Advanced Research and Technology. It is the responsibility of this office to develop the technology for present and future NASA missions. The range is broad—from new propulsion systems, to heat shields, to life support systems. The work is necessarily both fundamental and applied. Especially here there is great promise for civilian applications in the not too distant future. Good examples of the areas from which applications already are coming are the communication satellites and the weather satellites.

All this is a massive program. Its difficulty, its shape, its size are not at all indicated by this brief description. As the program has been laid down over the past few years, we have begun to understand that the space effort is intimately related to all other aspects of our life. It is, in a sense, a strong coursing current running through the total of American life, affecting our society in ways that were not foreseen and causing consequences which were unintended; as we are increasingly aware, it is a current that must be put to the best advantage of this nation. It is a current that can carry many loads.

The space effort is at once a product and a leading edge of the general advance of science and technology. It is very important that we consider it in this light and so put in perspective some of the sensational aspects that have gathered around it. The technical ability to go into space appeared in the same way as did the ability to introduce automation into the coal mines and steel making, for instance. These things were planned only in the sense that we became committed years ago to the pursuit of science and technology. For all the problems involved, we would not, even if we could, turn back the clock. We must go forward and solve the problems of automation and underemployment, of the requirement for new levels of technical training, of fast-changing products and markets. To this end we must bring to bear as much as we can of what we are doing in the space effort and what we are learning from it.

The space effort as a national effort must be related directly to the national problems of economic growth and well being. Broadly, there are two aspects of this problem. There is a national aspect, strictly speaking; for this we use the general measure of the annual rate of growth of the economy and its companion, the rate of unemployment. The other is the local or regional aspect. Our sparkling dynamic technology moves swiftly across the country creating boom conditions in some places and leaving behind in other places established industrial areas in a state near desolation. This creates not only local hardship, but also national waste. Ways must be found by which local areas can look ahead, anticipate new developments, and acquire the capacity to adapt to new technical and social requirements. The space effort must be related in a close way to the solution of both the national and local problems.

In this sense, then, the space effort is not only a major factor in the advance of science and technology, but is also a national resource. Quite apart from the space exploring mission is a hard-driving practical research and development effort of broad and varied impact. The requirements for space exploration begin in the field of anatomy and run virtually the whole gamut of scientific and technological interests from new sources of power to zero gravity.

Further—and this is of major importance—those objects made for space travel receive no compromises from the harsh environment in which they must operate. This means that a very large part of the total space effort is conducted at the very leading edge of the state of the art, and in fact is continually extending the state of the art. Another way to recognize the far-reaching requirements of the space program is to look at it in terms of the companies involved. A recent survey of nine major contractors revealed 11,000 first-tier subcontractors and suppliers—located in some 46 states.

An effort of such size, range, and sophistication, extending over at least a decade, cannot fail to have profound consequences. The effect of the space effort on the American economy will be altogether comparable to the impact of World War II. It is moving glacially across the full range of our activities, calling forth both fundamental investigation and technical ingenuity to solve a host of problems and to produce new techniques and processes of manufacture, new modes of organization, new measures of reliability, new qualities of materials, and ultimately new products and services.

NASA is committed to a hard-driving effort to transfer the useful fruits of our research and development effort to the private sector of the economy and to the solution of the problems with which we are confronted today. We are committed first because the Space Act in its wisdom requires it: "The Administrator is directed to provide for the widest practical and appropriate dissemination of information concerning its activities and the results thereof." There are other parts of the Space Act that also apply, including its general spirit. We are also committed because we are mindful of the major share of the Nation's research and development effort that is occupied by the Federal agencies, and it is essential that the maximum value be wrung out of this effort.

We are also committed because, given the probability that a large Federal research and development program will continue into the foreseeable future, a major effort at transfer must be made at some point in order that public policy decisions can be made on the basis of operations rather than speculation. If a potential worth the effort is there, if it is indeed feasible and practical to talk about such transfer, then we need to know it. If it is not, then we need to know that.

In NASA we are moving in a variety of ways to fulfill this commitment—or, more accurately, we are exploring ways. We have made certain starts, of which our association with this conference is one. We are hopeful that out of this conference will come indications of how we might proceed in more fruitful ways.

At NASA Headquarters the Technology Utilization group is working steadily on the problems involved in the transfer of technical information into our economic life. At each of the NASA field centers, an industrial applications officer and his staff study the work being done there and report on new devices, processes, and techniques that show potential for application elsewhere. One of the problems we are working on—and an extremely difficult one—is that of increasing the quantity of innovations reported by individual contractors. For example, Westinghouse has recently taken a contract under which it will study techniques of motivating such reporting by industrial contractors.

In a related field, the Midwest Research Institute is carrying on a pilot study of considerable interest: Members of the Institute's staff visited the NASA centers and identified a large number of potential applications. Midwest then selected the most promising of these applications and, by visits to central cities in six states in its area, presented these potential applications to business and industrial leaders.

The type of thing they are doing can be illustrated by the following example from Ames Research Center. In an effort to simulate the conditions under which a space vehicle reenters the atmosphere, Ames adapted for its use a stirred-arc gas heater. This heater employs a radial magnetic field to rotate an electric arc at high velocity between two circular water-cooled electrodes. Rotating the arc not only reduces electrode erosion to a minimum but also makes possible much higher heating efficiencies. Midwest Research Institute, in evaluating this item for industrial application, estimates that the use of such an arc heater to convert natural gas into acetylene may result in a considerable reduction in the cost of producing acetylene. There are added possibilities for use of this faster high-efficiency heater in the chemical and metalworking industries.

One other example illustrates a transfer that was made under auspices other than those of NASA. The Mercury capsule includes an infrared horizon-sensing device, and its principle has now been put to use in the steel industry to measure the diameter of steel rods as they flow through in their heated condition. This, we are told, represents a very substantial advantage in the process.

NASA is seeking ways to develop the participation by universities in this activity. To date we have made eight sustaining grants to universities, similar to the one that has been made to the University of California in Berkeley. With regard to the transfer of technical information, the understanding between each of these universities and NASA is somewhat as follows: The university will undertake, in an energetic and organized manner, to explore mechanisms whereby the progress and research results achieved in space science and technology can be transferred to segments of industry and of the economy with which the university normally has close relations. This effort may include scholars from other universities and representatives from industry. In addition to an intensive effort on fundamental scientific and engineering problems related to the space effort, research is to be encouraged on ways to expand the quest for useful applications and on the economic and social impact of our national involvement in space exploration. The university will undertake to make the scientific community, as well as the industrial and business communities, aware of new opportunities for application of specific developments stemming from the space program.

We are not suggesting detailed procedures. We are not in any way trying to infringe upon the basic function and nature of the university. We are simply trying to be a broker in getting from the universities the best effort that they can make to show the Nation how to make this transfer—if indeed it is possible. We are enlisting the best brains and the best efforts of a number of very good universities to help solve an important national problem.

We have taken a slightly different tack at Indiana University. Under a NASA project grant, the Aerospace Research Application Center has been established there in the School of Business. The object is to place the managerial and administrative talent in the university in a close cooperative program with local industry, and to use the latter's competence in engineering and technology for this effort. The Center at Indiana will explore and test various approaches to the transfer of NASA's research and development results to industry, determine the most effective techniques and methods, and provide a quick feedback on these techniques and methods to NASA. The Center will use a computer facility to store data on applications of potential use to industry and will attempt to match that information to industrial needs on an expeditious basis.

We are also trying other approaches. It is clear that one of the most essential goals must be the bringing of industrial research people into direct contact with our research and development effort, so that they may study this effort closely and in terms of the interests of their own companies. To the fullest possible extent, we want to remove the middleman from this situation. We are, therefore, beginning to contact companies directly, seeking to have them send some of their best people to NASA to spend substantial time going over the work of our centers. Already one large national company has agreed to do this, and we are hopeful that others will follow.

It has become evident that we ought to take steps that will establish on a more permanent and longer range basis the interest of a city in this matter of transfer. We ought to encourage the organization in Oakland, for instance, of a group that would commit itself to perhaps a 5-year effort to study carefully the needs and potential of this local region and seek ways of utilizing new processes and new products from NASA's research and development work.

Beyond the purely technical application of the space effort—purely technical means here the transfer to business and industry—NASA accepts a responsibility towards the implications of the broader problems of American life. That is one reason this conference is in being. We feel that, to the fullest possible extent consistent with NASA's primary mission and with the Space Act, we should act to secure the widest application of our research to such problems as those considered at this conference. Particularly here, the techniques and methods of organization, as well as specific technological applications, are sought.

We are not so far along, perhaps, in this line as we are in the matter of direct transfer to business and industry, but we are working at it. Perhaps our most notable step to date has been through sustaining grants to the universities. We ask these schools to use their best efforts to bring economists, students of public administration and management, regional planners, and other social scientists into a working relationship with the scientists and engineers concerned directly with space research. We ask further that these scholars address themselves to the problems of American life generally, and especially to the manifestation of these problems in their own regional setting. We are frankly seeking to create a more viable process of interaction between the substance of the university on the one hand and the needs of business, industry, public administration, and community life on the other. We do not do this to infringe in any way on the basic function of the universities. What we are saying is that in the fast-changing modes of life in America today, in times when Oakland and other areas come to see the urgency of their problems, the university must somehow come forward and make a new kind of contribution and that this kind of contribution must be determined in interaction between the university and its immediate area. A grant to help promote such a relationship was made to the University of California in Berkeley. Economists and other social scientists have been brought into this group, and we are extremely interested and gratified at this development.

In these United States, it seems, we tend to run in cycles as between local interests and national interests. There was a time, not many years ago, when the word "sectional" was applied broadly and indicated the existence of basic regional differences. Then, particularly under the pressure of prosperity and the national feelings generated by World War II, we tended to move cyclically again to a more national basis—to remove, in many respects, regional and sectional differences and to remove, for instance, much of the emphasis on local developments. These differences were pushed aside by the overriding attention to the national developments in economy, science, and education. Today, we have a national market, a national economy; we have a national educational system in terms of standards. Yet, it seems, we are now back somewhat on the other turn of the cycle. The fast movements that have developed in this country—the coming together of people, the new demands for education, for training—have laid on the local areas very heavy responsibilities and have brought forth a new regional emphasis on development and advancement. As we in NASA see it, this meeting in Oakland is really a reflection of a concern with local urban problems that extends from Boston, Pittsburgh, Cleveland, Detroit, and Chicago all the way to the west coast. The large cities and their hinterlands are mobilizing and coming forth to ask, "How do we solve these problems? How do we stay alive? How do we move forward during the next decade?"

NASA has as its primary mission the mastery and exploration of space. However, we in NASA are committed in the fullest possible sense to working with the regional efforts that are now underway, and with others which will come into being, because we feel that this is the way to balance—to equilibrium—in the American society.

AN INSIGHT TO THE SCOPE OF THE NATIONAL SPACE EXPLORATION PROGRAM

D. D. Wyatt

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THE UNITED STATES is developing a total program of space exploration and utilization which is of a much greater scope and magnitude than is generally appreciated. In this discussion, only the more obvious aspects of the program in terms of currently projected flight missions will be described.

The overall scope of projected flight missions is, in itself sufficiently broad to make it difficult to show the interrelationships of the many parts to the whole. One approach that is sometimes used is to describe the elements of the overall program in terms of the obvious categories of unmanned scientific exploration missions, unmanned applied or operational satellites, and manned exploration of space. This paper will, however, seek to show the program interrelationships more clearly by grouping missions along a geographical base in the case of space exploration with a concluding discussion of applications satellites.

The basis of classification of exploration missions is identified in figure 1. Three general regions are of interest. That part of space near the earth is obviously affected by the presence of the earth with its attendant gravitational, magnetic, and electrical fields. Although conditions here are not representative of the bulk of the universe, it is the region that will receive the major share of scientific attention for some time to come because of two overriding factors: it is that immediate part of the base cosmos which is of primary egocentric concern, and it is the most accessible part of space.

Exploration of the near-earth region is predominantly carried out by sounding rocket and earth-satellite missions. The sounding rocket, a relatively inexpensive device, is useful for giving us a set of measurements of space properties from about 50 to several thousand miles above the earth at essentially a single moment of time as the payload arches skyward and falls back to earth. For longer, synoptic measurements of the properties and effects of near space we resort to the use of the earth satellite. These spacecraft may make from one to thousands of orbits in their elliptical paths around the earth focus point.

Our interest runs beyond the near-earth reaches of space. In particular, the moon, our closest space neighbor, and the nearby planets Venus and Mars are attainable and, hence, attract our interest. Our missions to these bodies require escape from the earth and are known as probes, lunar, planetary, or simply interplanetary depending on their destination. Let us examine the near earth, lunar, and planetary missions in turn.

NEAR-EARTH EXPLORATION

Exploration with earth-satellites has already reached large proportions. Up to October 4, 1962, just 5 years after the first space launch, there had been launched 49 earth satellites, exclusive of those by the Department of Defense. Of these, 27 were by United States vehicles, 22

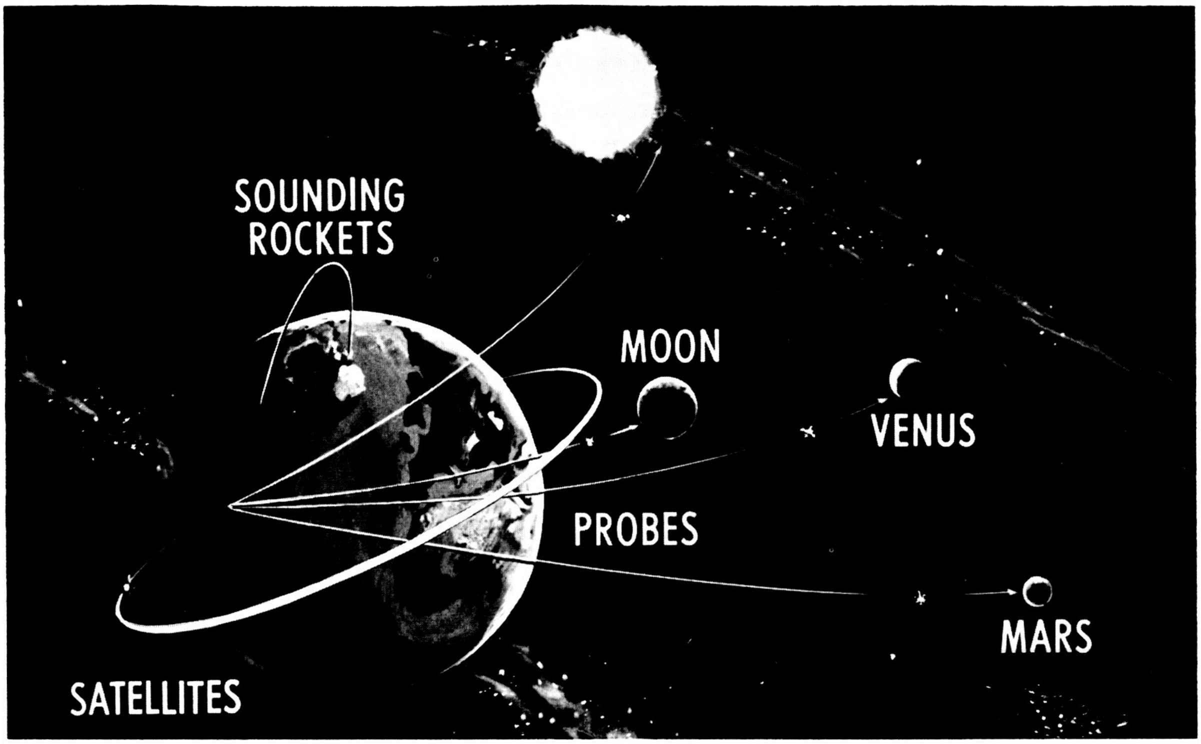


FIGURE 1.—Sounding rockets, satellites, space probes.

were by the Russians. Seven of these flights were manned, the rest were unmanned instrument carriers.

Most of the U.S. satellites, to date, have been relatively small and, in general, have contained instruments associated with a single scientific area of interest. These types of vehicles will be continued into the future to extend our knowledge of space properties. We are, however, now entering a period in which much larger, more complex satellites will afford us an opportunity to make simultaneous, interrelated measurements of a number of space properties.

The first of these "observatories" (for their capacities warrant this terminology) was flown in March 1962. Figure 2 shows the Orbiting Solar Observatory. This satellite, with about a dozen experiments on board, is still yielding useful data as it examines the sun day in and day out. The upper portion, covered with purplish tinged solar cells for converting sunlight to electrical energy, is pointed at the sun, whenever the sun is in view. When the satellite dips into the earth's shadow, it relaxes until daybreak when it once again seeks out and holds the sun for its sensors. Part of the stabilization is achieved by the spinning lower segment of the satellite with the control gas jets at the end of the revolving arms.

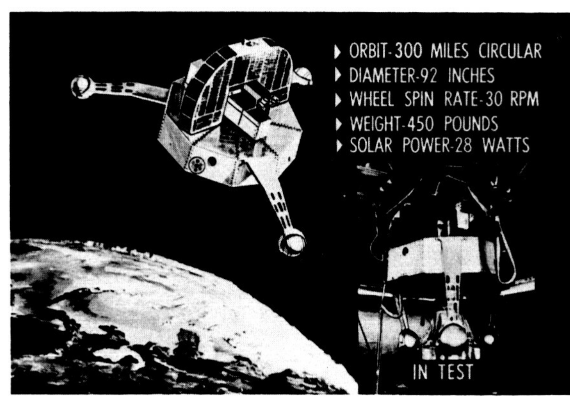


FIGURE 2.—Orbiting Solar Observatory.

Our next step in the area of scientific observatories is shown in figure 3. This spacecraft, weighing about a thousand pounds, will examine the geophysical properties of space—that is, those properties associated with or influenced by the presence of the earth. The figure shows the successive attitudes of one version of this observatory when flying an eccentric path out to about one-fourth of the way to the moon. Whereas the Solar Observatory was stabilized to face the sun, this spacecraft will be earth-stabilized so that one set of the score of experiments will always look back at the earth. Because of this constant orientation, other experiments can be carried that will always point to space and yet others at right angles to the plane of motion. The large paddles covered with solar cells will always point at the sun, so that some experiments mounted on the paddles can be constantly solar oriented.

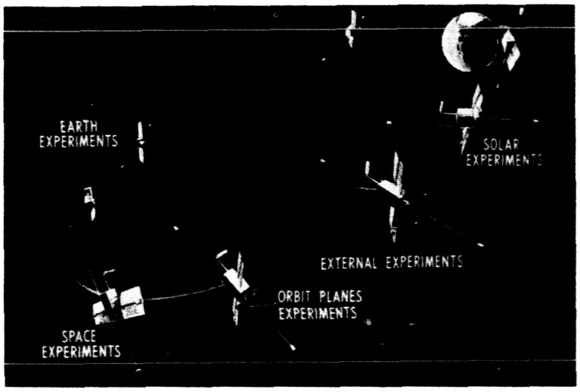


FIGURE 3.—Eccentric orbiting geophysical observatories.

A spacecraft similar to the one shown in figure 3 will also be used in a nearly circular polar orbit to yield data on space properties near the earth's magnetic poles. The first of the Geophysical Observatories should be launched in less than a year from now.

Our present series of observatories will be rounded out by the Astronomical Observatory shown in figure 4. This 3,500-pound spacecraft will be oriented toward the stars in its nearly circular orbit around the earth. Now under development, and expected to be flown within about 2 years, this remarkable spacecraft will be used for long-term astronomical observations of the universe, principally at energy wavelengths that do not penetrate to the surface of the earth.

These three observatories will each be launched at intervals throughout this decade to give us long-term continuous measurements in the solar, geophysical, and astronomical areas. Augmenting these will be numerous flights of smaller, more specialized spacecraft for near-earth scientific measurements.

True exploration of the near-earth reaches of space will largely fall in the domain of the unmanned spacecraft. This does not mean that man will not have an active role in this region; however, it does mean that until there is a future clarification of manned space laboratory missions, the role of man in satellite flights will focus primarily on his behavior when subjected to space conditions and on the development and proof-testing of the technological systems required to sustain him from launch to recovery. In point of fact, we can more readily identify scientific exploration tasks requiring astronaut participation in terms of lunar or planetary exploration. Our current near earth missions are, therefore, primarily focused on the solution of problems anticipated in these long-term missions.

The first steps of manned flight are already well known. Figure 5 shows a cutaway view of the now familiar Mercury capsule. Initially designed for three earth orbits, the Schirra flight extended it to nearly six orbits, giving a 9-hour exposure to near-earth space environment. This spring we will fly a slightly modified version of the Mercury capsule for eighteen orbits or more, thus acquiring further information on the actions and reactions of men to more extended periods of exposure to weightlessness. The modifications will consist, principally, of additions of expendable supplies. The mission will still be restricted to a single astronaut.

In order that we may acquire more extensive information on the effects of long-term space exposure on astronaut capabilities, concurrently evaluate flight systems required for this longer duration flight, and develop advanced mission capabilities involving man's direct participation, we will initiate our first Project Gemini flights in about a year.

As shown in figure 6, the Gemini configuration will be geometrically similar to the Mercury

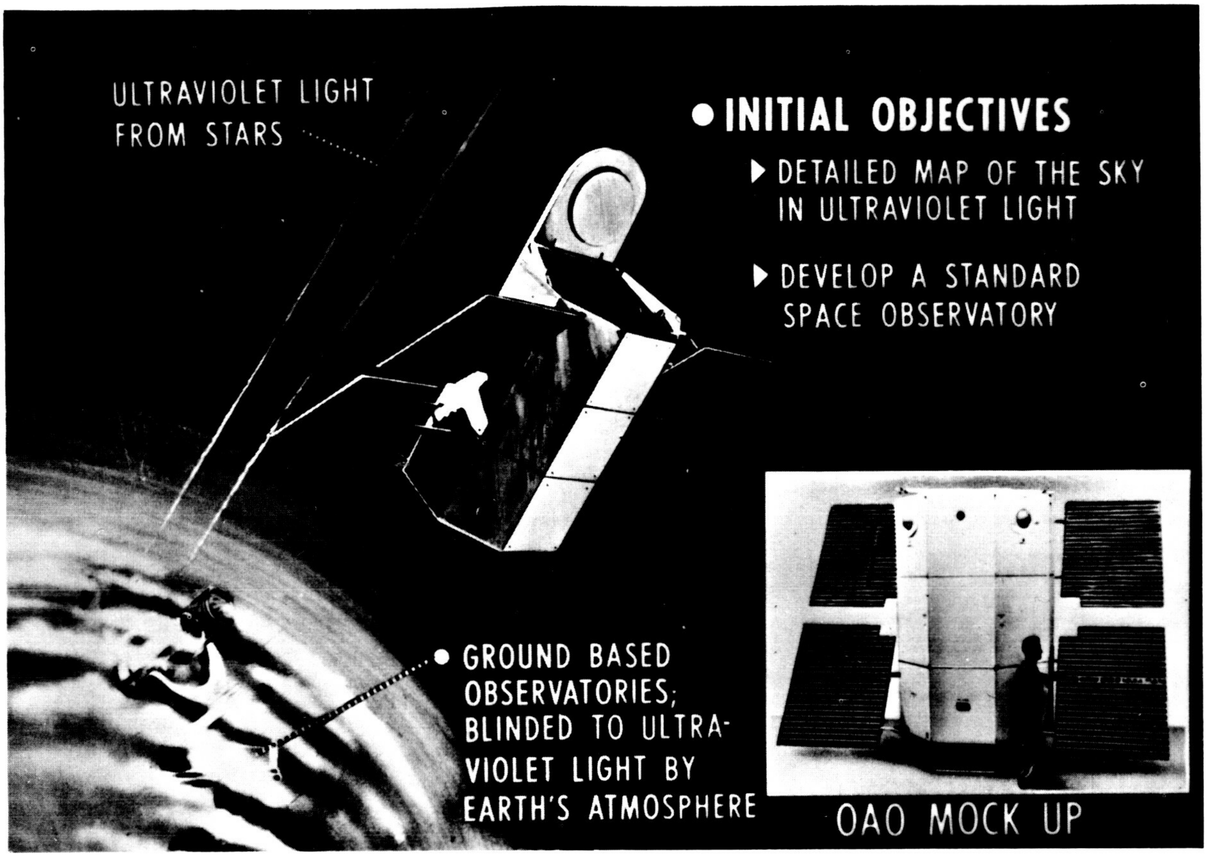


FIGURE 4.—Orbiting Astronomical Observatory.

spacecraft. It will differ significantly, however, in being large enough to accommodate two astronauts simultaneously. By providing a copilot, as it were, we feel that we can safely and objectively proceed to flight durations of a week or more.

In addition to providing a laboratory for the study of the effects of long-duration flight on man, Gemini will provide us a powerful technological device for developing the art of rendezvous and docking in space. Rendezvous is here defined as the task of maneuvering into close proximity two spacecraft separately launched into space, and docking as the task of connecting together those spacecraft to form a composite machine. The task of landing men

FIGURE 5.—One-day manned flight.

FIGURE 6.—Gemini spacecraft.

on the moon and returning them safely to the earth will be greatly expedited by utilizing rendezvous and docking techniques.

In the Gemini program a target spacecraft will be launched into earth orbit and, after confirmation of its ephemeris, will be followed by the insertion of the two-man Gemini capsule. Through a combination of ground- and airborne-tracking information, the astronauts will maneuver the two spacecraft into an actual physical coupling. Insofar as Gemini itself is concerned, no essential mission capabilities will result from this docking procedure. The significance will become apparent in the manned lunar mission or, when missions become defined, for crew or supply transfers to manned orbiting space stations. However, as one phase of Project Gemini, we will attempt to have one astronaut actually leave the capsule in space and perform simple tasks in the vicinity of the orbiting capsule, orbiting at 18,000 miles per hour.

LUNAR EXPLORATION

Before we consider the problems of manned lunar flight, let us examine the scientific programs that will precede that event.

We are now in the process of carrying out our first-generation attempts at lunar exploration. The spacecraft we are using is shown on the right in figure 7. About a year and a half ago we launched two Ranger spacecraft for experimental verification of the design concepts. Although neither launch resulted in the preplanned highly elliptical trajectory, we were able to confirm the basic validity of Ranger. In January 1962 we launched the first of our Ranger spacecraft at the moon. Through an uncorrectable velocity overshoot at launch, we missed the moon by about 23,000 miles, a distance too far to permit employment of the Ranger instrumentation. On a second attempt in April 1962, we had a highly accurate launch, but malfunctions within the spacecraft made it impossible to activate the systems requiring onboard control. As a consequence the spacecraft traveled out to the moon without midcourse correction and impacted on the back side with no opportunity to exercise our instrumentation.

Our third attempt to perform the lunar impact mission with Ranger during the fall of 1962 also ended in failure as a result of internal spacecraft difficulties. We will continue further

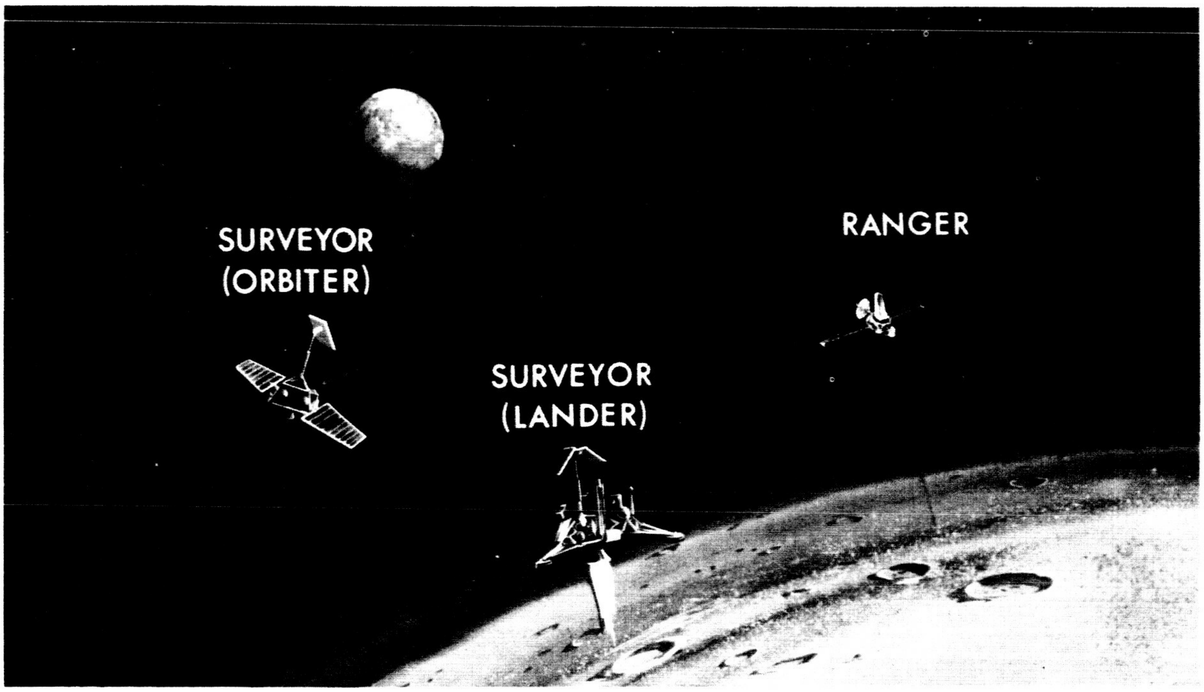


FIGURE 7.—Unmanned lunar spacecraft.

shots in the Ranger series because of the great importance of the data that can be obtained from this mission.

As the spacecraft approaches the moon on a collision course it will reach an ultimate impact velocity of about 6,000 mph. This impact will, of course, result in an instantaneous destruction of the spacecraft. Several thousand miles from the moon, however, the spacecraft will be alined so that a series of closeup moon surface photographs can be taken with video-cameras and radioed back to earth. Every 13 seconds, during the final plunge, a new photograph will be transmitted. These will naturally give a successively increased enlargement of a small part of the moon's surface. These will result in our first real closeup look at the lunar surface terrain.

The best lunar photographs from earth observatories do not yield a resolution of details less than about 1,500 feet across. The Ranger photographs should improve this resolution to a few feet. From this improved surface data we will be able to determine the engineering details required in the landing and stabilization system of manned lunar spacecraft that must maintain landing attitudes permitting subsequent take-off.

Some Ranger missions will not be completed after photographs are taken prior to impact. In some flights, when the main spacecraft is about 10 to 15 miles from impact, a small detachable package will be retrofired backwards to a resultant zero velocity relative to the moon. Under the pull of the moon's gravity, this package will then fall freely to the surface. The instruments, enclosed in a thick balsa-wood crushable casing, will survive the impact and will radio data from the moon's surface for about a month.

In the Ranger attempts to date, the survivable package has contained a single-axis seismometer to measure lunar surface tremors or moonquakes. The absence or presence of tremors, and the character of those recorded, will contribute greatly to an understanding of the interior composition of the moon, and hence give valuable clues to its origin and formation processes.

Subsequent Ranger spacecraft will have several versions, depending on the developing outcome of the flight program. In our next series, starting late in 1963, all survivable equipment will be removed to permit the inclusion of more advanced photographic and electronic readout equipment. In this version, we hope that exclusive concentration on the photographic mission will improve the quality and quantity of photographs of the moon's surface.

It was indicated that Ranger is our first-generation lunar exploration vehicle. The Surveyor lander, our second-generation effort, is already under development. Surveyor is a soft lander. That is, instead of impacting to destruction with, at best, a small survivable portion, the entire spacecraft is decelerated by a relatively large retrorocket and is brought to rest on the lunar surface. The actual sinking speed at impact should not exceed that of modern transport aircraft as they touch down on a runway.

The Surveyor spacecraft will have a landed weight of about 700 pounds, almost the injected weight of Ranger. Consequently, relatively sophisticated lunar experiments will be possible. These will vary among the successive Surveyor landings, but will include radioactivity and radiation measuring devices and instruments for detecting the presence, if any, of a lunar atmosphere. Several television cameras will be capable of taking photographs ranging from microscopic closeups of the soil at the landing point to panoramic pictures of the moonscape in the vicinity of the spacecraft.

One of the more interesting pieces of equipment contemplated for later versions of Surveyor will contribute to an understanding of the lunar geology. A core drill, similar to an oil-well drill, will be extended from the spacecraft to take a 5-foot-deep core sample of the lunar crust. By transporting the sample through an analyzer it will be possible to radio the chemical composition of the moon's crust back to earth.

The surface photographs obtained from the Surveyor lander together with the closeup approach photographs from Ranger should give us a reasonably detailed understanding of lunar surface conditions at a number of points. In order to complete our landing site selection for eventual manned missions, we may find it necessary to correlate these detailed regions with a complete moon surface reconnaissance. A vehicle to do this may be a second version of Surveyor, the orbiter. The surface instrumentation would be replaced by high resolution TV cameras and the modified spacecraft inserted into a satellite orbit around the moon. By this technique the complete lunar surface could be photographed. Other reconnaissance vehicles are also being studied.

Ranger is our first-generation lunar exploration spacecraft; Surveyor will be our second; and a manned system will be our third. These generations are fairly compressed, inasmuch as we expect to make our first manned lunar landings before this decade is out.

APOLLO

The lunar landing mission will be the culmination of the mightly Project Apollo. As shown in figure 8, Apollo will actually consist of a number of stepping-stone missions, each impressive in itself. By mid-decade we will be flying a three-man crew in earth orbit. Besides adding to our store of knowledge about crew reaction and performance during flight durations of several weeks, these flights will provide verification of our component technology and will serve as crew-training missions. A little later we will practice the capsule separation, rendezvous, docking, and crew transfers later to be employed in the lunar landing mission. Only after this experience is gained will we be ready to fly out to the distance of the moon and reenter the earth's atmosphere at 25,000 mph.

In all probability the early lunar flights will only accomplish circumlunar flight, with perhaps a low-level visual reconnaissance of the lunar surface during orbital passage around the moon. Actual lunar landings will follow.

On the left of figure 8 is shown the launch package for the lunar landing mission. A command module will hold three astronauts during launch, the trip to the moon, and the return to earth. This is the only portion of the spacecraft that will finally reenter the earth's atmosphere and be recovered. It is followed by a service module containing various supplies and

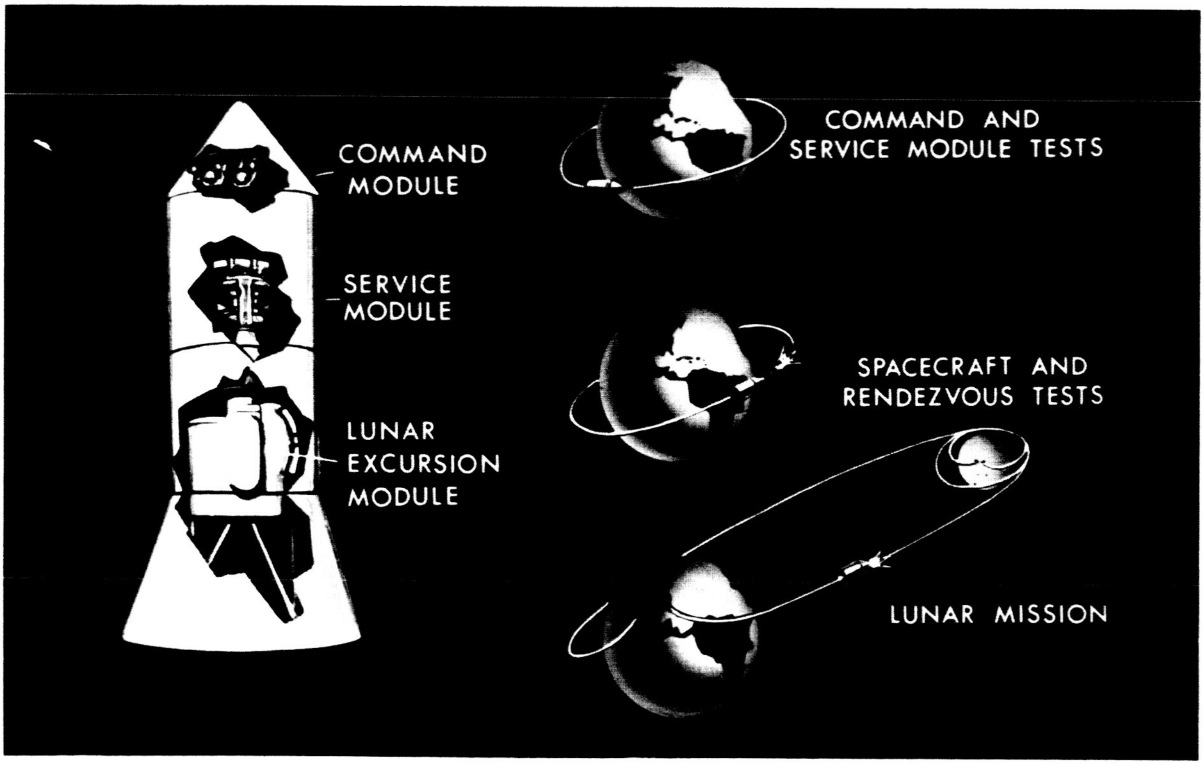


FIGURE 8.—Apollo.

the rocket used in slowing down the overall spacecraft to enter lunar orbit and in accelerating the command module for return to the earth. The last module is the vehicle that will be used for the actual lunar touchdown by two of the three astronauts.

The rather complex steps of the actual lunar landing and return are summarized in figure 9. After injection from the earth on the escape trajectory to the moon, a low orbit will be established around the moon. Two of the three astronauts making the journey will then transfer from the command module, or main spacecraft, to the second spacecraft which is designed solely for lunar landing. This lunar excursion module will be separated from the command module and will be brought to rest on the moon's surface.

After a 1- or 2-day exploration period, the lunar excursion module will be fired from the moon's surface back into a lunar orbit trajectory corresponding to that of the command module. The two spacecraft will rendezvous, dock together, and the two moon explorers will transfer back to the command module. Then, leaving the excursion module behind, the command module will be inserted into a lunar escape trajectory back towards the earth.

There will be no deceleration of the returning capsule by retrorocket. Aerodynamic braking will be the sole means of reducing the velocity from the 25,000-mph reentry speed in the earth's atmosphere. With the moderate lift aerodynamic characteristics of the Mercury-shaped capsule, this will require penetrating the earth's atmosphere within a corridor about 40 to 60 miles high, or a corridor only about 1 percent of the earth's radius. The spacecraft will be piloted down this corridor to one of several preselected landing areas on the earth. These areas will be on land, in contrast to the water impact zones of the current Mercury program.

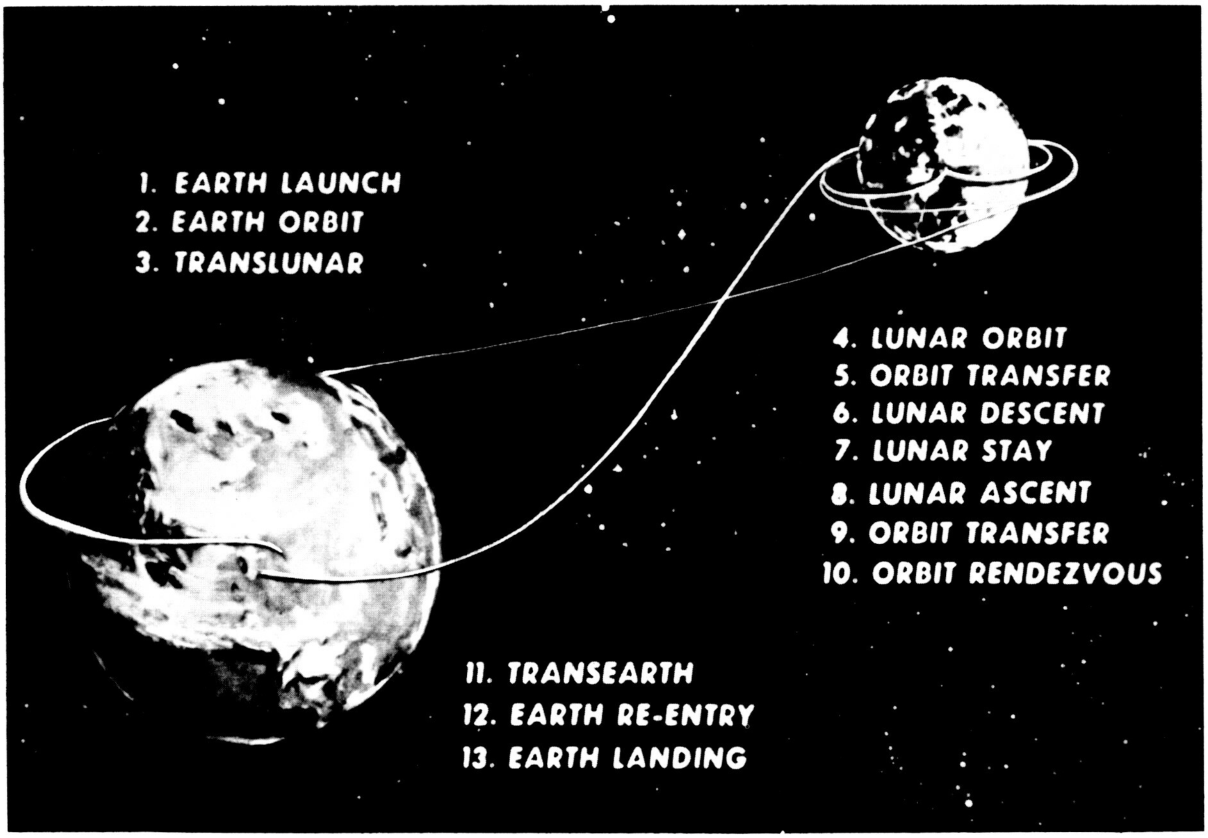


FIGURE 9.—Lunar orbit rendezvous mission.

The physical configuration of the spacecraft injected toward the moon can be seen in figure 10, representing the "unpackaging" of the spacecraft during lunar transit. For safety reasons the command capsule, housing the three-man crew, will be stored in front of the lunar landing module during launch, so it could be separated from the launch rocket in an abort maneuver in case of impending explosion of the rocket. When the escape trajectory is established the command and service modules will be turned until they are finally fastened in a face-to-face attitude to the lunar excursion module. This will permit the two landing crewmen to transfer once lunar orbit is established. After this docking, the spacecraft will be separated from the injection rocket stage.

Figure 11 illustrates the entry of the combined spacecraft configuration into a lunar orbit about 100 miles above the moon's surface. The deceleration from approach speed to the orbital velocity will be achieved by retrofiring the large rocket motor contained in the service module.

After the lunar orbit path is established, two of the three astronauts will transfer themselves from the command module to the lunar excursion module as illustrated in figure 12. They will simply move through a connecting hatch to the lunar excursion module. There is no "up" or "down"; there are weightless conditions. At the proper moment they will separate the lunar excursion module and, by retrofiring a braking-stage motor, will descend to the lunar surface as shown in figure 13. Their descent will terminate in a hovering maneuver a short distance above the surface from which they will be capable of making a final landing site selection within a radius of several thousand feet. The main motor will then be throttled for the final gentle landing.

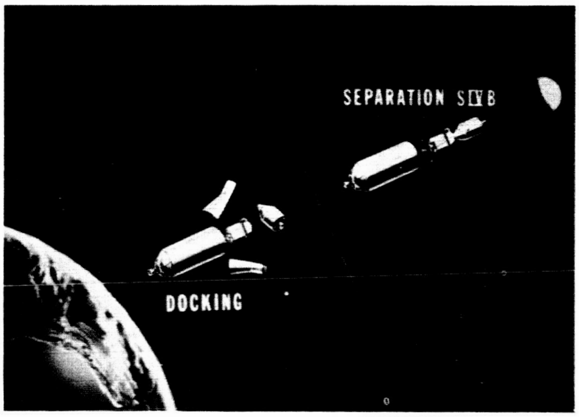


FIGURE 10.—Docking in transit.

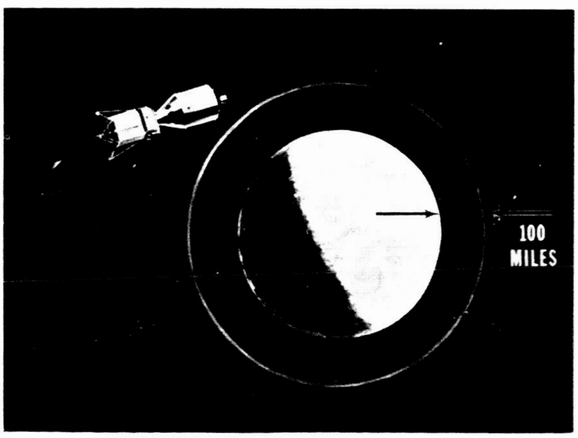


FIGURE 11.—Entering lunar orbit.

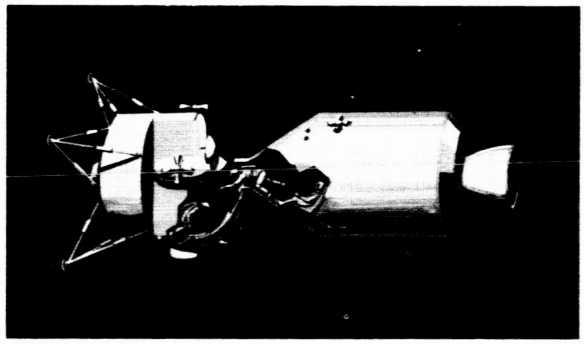


FIGURE 12.—Transfer to LEM.

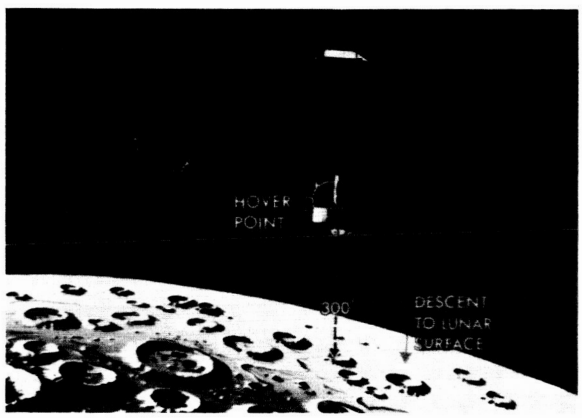


FIGURE 13.—Lunar descent.

able time for a Mars flight will come in the fall of 1964. We are now firming up our spacecraft concepts for the coming opportunities at both planets.

On the right in figure 17 is the probable next planetary spacecraft. The basic mission will be similar to that of Mariner II—that is, a fly-by in close proximity to the planet. In the case of Mars, the greater distances from the sun will require larger solar panel arrays to generate the on-board power—hence the greater number of panels.

In addition to the simple fly-by, however, we hope to be able to incorporate a detachable "pod" or capsule that can be aimed to enter the planetary atmosphere as the main spacecraft passes. Data on atmospheric conditions and on planetary surface properties would then be relayed back to the earth via the main spacecraft. We are also looking down the road a few years to determine mission capabilities when the very large boosters that were shown in figure 16 become available. With these large boosters we will be able to consider simple missions to planets other than Venus and Mars as well as much more complex and profitable missions to these two closest planets.

Having discussed the firm elements of our programing in the area of space exploration using manned as well as unmanned spacecraft, let us turn for a brief look at our projects aimed at the use of space for practical purposes to enhance man's living and operating capabilities here on earth. At the present time we do not visualize these kinds of operations being conducted except by earth satellites. Two areas dominate our attention: weather-observation and communications. We are, however, also closely examining Navy experiments with the Transit navigational satellite to determine the applicability of this system to international commercial uses.

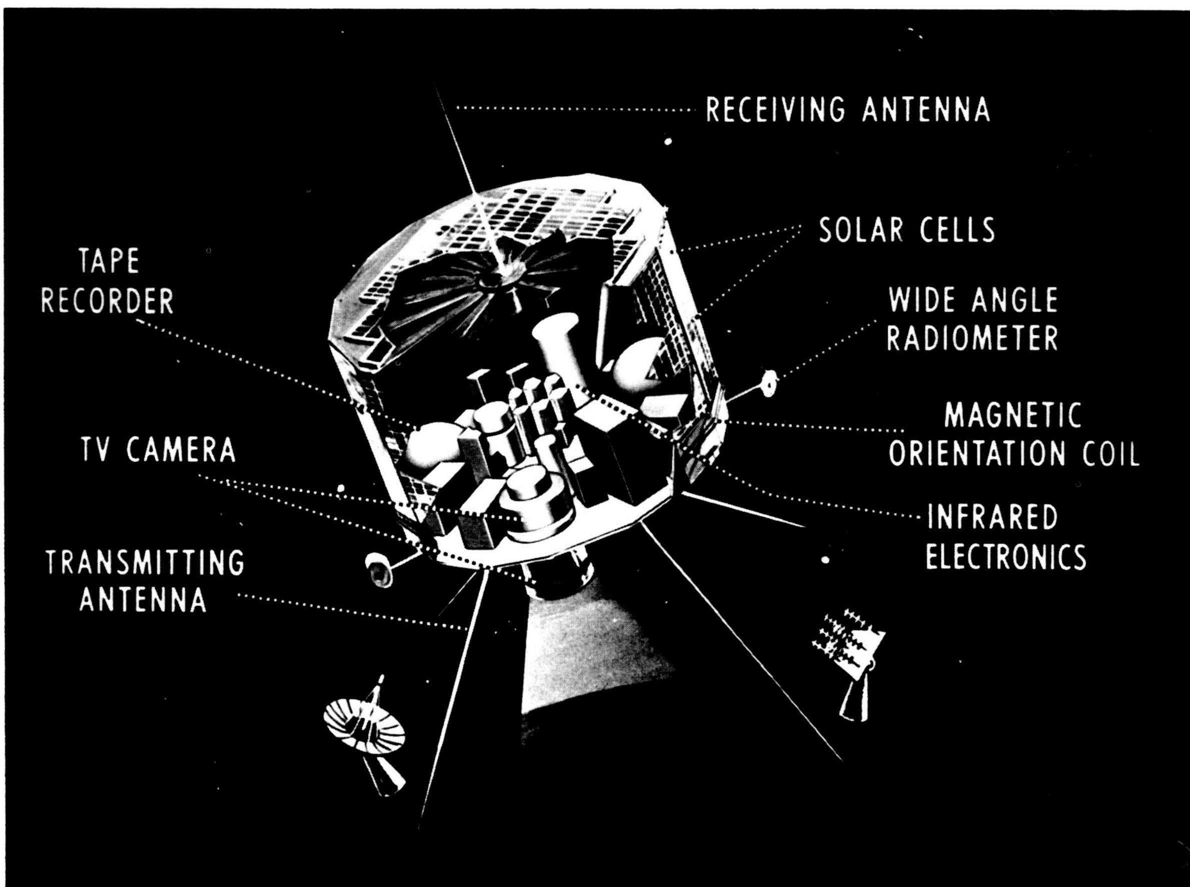


FIGURE 18.—Tiros.

METEOROLOGICAL SATELLITES

There appears to be a bright and definite future role for weather observational satellites, both for use in day-to-day weather forecasting and as a platform for acquiring basic new meteorological data that may markedly improve long-range forecasting techniques.

This country has already launched six of the Tiros satellites shown in figure 18. Two of them are presently operating simultaneously. These are relatively simple experimental devices. The solar-cell-powered spacecraft are spin stabilized and hence are space- rather than earth-oriented. As a consequence, the video cameras, used to record cloud formation pictures, only look at the earth during part of each satellite orbit. The pictures taken during the part of the orbit in which the earth is visible and in sunlight are stored on tape for readout on command from receiving stations located on the East and West coasts of the U.S. In some of the Tiros spacecraft additional infrared detecting instruments have been carried for fundamental measurements of the temperature distributions and resulting heat budgets around the earth.

Although the operational capability of the Tiros spacecraft has been limited, astounding success has been achieved in acquiring useful weather-forecasting data. Several hundred thousand individual cloud photographs have been transmitted back to earth. A large fraction of these have been analyzed by the Weather Bureau within a few hours of being taken and the results have been incorporated into regular weather analyses.

Both the limitations of the Tiros spacecraft and the potential value of an improved meteorological satellite system are revealed by the global cloud analysis data in figure 19. Based on a composite of photographs taken during one 24-hour period, the figure shows, on a large scale, what can be achieved by the weather satellite. Although limited by the satellite orbital and orientation characteristics of Tiros, seven major weather disturbances were observed during this 1-day period. The gross hemispherical weather systems indicated here are by no means representative of the local detail which can, and is, being developed from the weather pictures.

FIGURE 19.—Global cloud analysis, September 11, 1961.

NASA, in cooperation with the Weather Bureau, is developing a second-generation weather satellite that will yield data that will help fill up the gaps on this map. This Nimbus satellite is shown in figure 20. The sensory instrumentation, which will not differ markedly from that carried in Tiros, will consist of improved video-camera systems and infrared scanners in the early versions. The principal differences in the spacecraft arise from the incorporation of earth

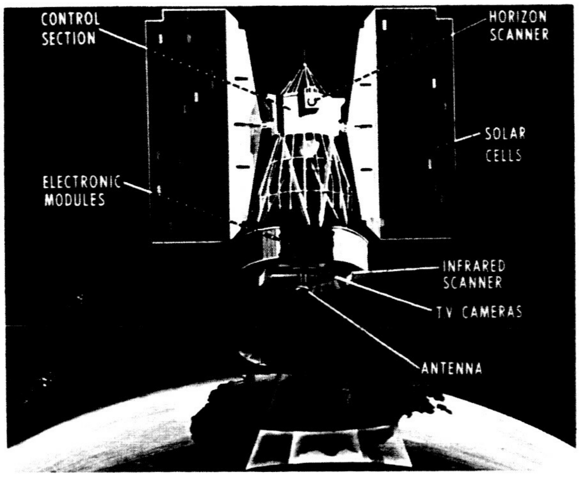


FIGURE 20.—Nimbus meteorological satellite.

stabilization of Nimbus. Control sensors will keep the cameras continuously pointing at the earth. When flown on a near polar orbit, therefore, Nimbus will give pictures of the weather over most of the earth every 12 hours.

Because the solar cells must continuously point at the sun as the spacecraft revolves on its axis to maintain earth orientation, the cells are mounted on paddles which will revolve relative to the spacecraft body.

The first Nimbus should fly in less than a year. After a developmental period of several years, the country can probably expect the incorporation of a continuously operating weather satellite system in our weather prediction service.

COMMUNICATIONS SATELLITES

The second area of space application that seems fairly near fruition is the field of communication satellites. Over 2½ years ago NASA launched a passive sphere known as Echo which permitted experimental transcontinental and transoceanic communications via space. Although possessing the virtue of having no airborne electronic components in the communications link, the passive system suffers disadvantages in terms of high power ground transmitter and ultrasensitive ground receiver requirements, inasmuch as the communication signal is simply reflected from the satellite without power boost.

The recent successful launchings of the AT&T Telstar and the NASA Relay have dramatized communication satellite capabilities when spacecraft signal amplification equipment is incorporated. Figure 21 illustrates the typical elements of these "active" communication satellites. A relatively modest power level can be used to beam a ground signal to the spacecraft. It is received, amplified, and rebroadcast by

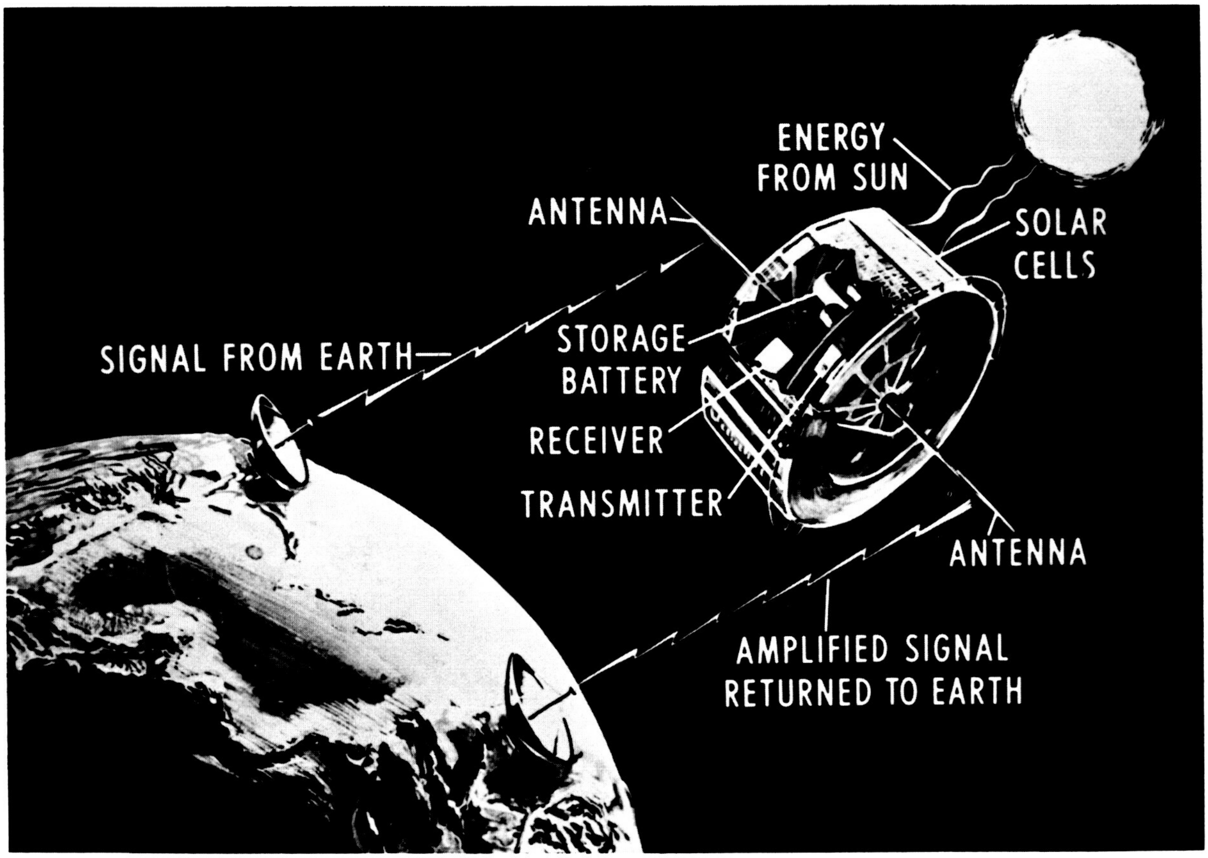


FIGURE 21.—Active repeater satellite.

the satellite. This power boost to the signal minimizes the required receiver capability.

Although Telstar and Relay have shown the potentiality of active communications satellites, they have not resolved the technical questions as to the best kind of a satellite system. At moderate altitudes, where the satellite can be spin stabilized without serious signal fluctuation at the ground receiving station, the deleterious effects of concentrations of energetic particles in the great radiation belts may reduce electronic component life to an unprofitably low level. Also at these altitudes larger numbers of satellites will be necessary in order to maintain continuity of communication between ground points.

If the satellite altitude is raised, however, to the synchronous height of about 22,000 miles in order to minimize the numbers of satellites and the effects of radiation belt damage, a requirement is introduced to increase greatly the satellite on-board power, or stabilize the satellite relative to the earth, or electronically point the antenna output pattern at the earth at all times. There are major technological problems to be overcome with any of these alternatives.

Although passage of the Communications Satellite Bill has made it clear that operation of a global communications system via satellites will rest in the hands of private industry, there is a major governmental role still present in the exploration and solution of basic research and development problems. The NASA program in the active communications satellite area is continuing strongly, therefore, with Projects Relay and Syncom in the intermediate and synchronous altitude ranges, respectively, to further the state of the art so that the world can enjoy the earliest commercial utilization of space for international communications.

PLENARY SESSIONS

Chairman: **C. Easton Rothwell**
President, Mills College

GOALS AND POTENTIALS OF SCIENTIFIC RESEARCH IN SPACE

Dr. Homer E. Newell

DR. HOMER E. NEWELL, Director, Office of Space Sciences, NASA. Formerly: Deputy Director of Space Flight Programs, NASA; Superintendent, Atmosphere and Astrophysics Division, U.S. Naval Research Laboratory; Faculty member, University of Maryland. Recipient, American Rocket Society Pendray Award, and Space Flight Award of American Astronautical Society; Fellow of AAAS and American Astronautical Society. Harvard University (BS, MA); University of Wisconsin (PhD).

THE GOOD ENGINEER must know his materials. In order to put into practice his ideas he must know what techniques, instruments, equipment, materials, and processes are available to him, and he must understand the facts of nature and the basic laws that govern his use of them. In other words, progress in the solution of new problems must rest solidly on accomplishments of the past.

Anyone who undertakes to apply human learning and its products to the solution of practical problems is in a very real sense an engineer. This is as true in the case in which the problem is social or political or economic as well as in the more traditional cases of civil, mechanical, electrical, electronic, aeronautic, mining, or marine engineering. In the latter cases the problems are usually well defined, and there exists a wealth of codified information and experience with which to tackle them. There are complete libraries of reference material, handbooks, textbooks, and catalogs, while a massive industrial complex stands behind the engineer ready to assist in the accomplishment of his goals.

In the former case of social, political, and economic matters, the problems that face those who would engineer a solution to them are just as important as those that occupy the attention of the more conventional engineer. Indeed, since they often concern the viability of our communities, our nation, and even our civilization, they are of transcendent importance. And they are often immeasurably more difficult to solve.

Even the problem sometimes defies clear-cut definition. And the applicability of past experience is not always clear. Nevertheless, one constructive step in approaching all these problems is to know what one has to work with. In our present day, one of these tools is the rapidly developing space program.

The budget of $3.7 billion for the current fiscal year and the requested $5.7 billion for the next fiscal year are sizable sums of money, approaching 1 percent of the Gross National Product in magnitude. But perhaps even more important than the absolute magnitude of these sums is the leverage they exert or can be made to exert on other more general activities and associated resources. Although the effect of the space program on the total national scene may be quite modest, in certain localized regions it can be quite large. For example, in the last 3 years NASA contracts in the southwestern United States have amounted to $1.4 billion, and about 90 percent has gone to and through contractors in California. It appears at the present time that in fiscal year 1963 about 47 percent of all NASA prime contracts will go to California firms. Some share of this goes to the San Francisco Bay Area.

It is not within my competence, or that of most of my colleagues, to understand how to approach the solution of problems of regional development and growth. It would be out of order for us to attempt to suggest solutions. But we can describe one of the tools available. That is, of course, the space program. Our purpose is to promote an understanding of the scope, objectives, accomplishments, and potentialities of the space program in the hope that social engineers will discern how this tool can be used along with others in promoting the growth and progress that we all desire.

The implication and scope of the total national space program were described in the two preceding papers. The purpose of this paper is to review one aspect of that total program, namely, space science.

THE PROCESS OF SPACE SCIENCE AND ENGINEERING

Basic science has as its principal objective the advancement of fundamental knowledge about our universe. The results of basic science provide the foundation on which our great engineering and technological applications rest. At the same time, an important result of engineering and technological progress is the ability to do better basic science. All around us in this modern age we see examples of the product of engineering and technological skill serving the cause of science which in return serves the cause of engineering. Some examples are: the tremendous range of electronics instruments which are indispensable to the modern scientist; the huge accelerators and the modern nuclear reactors that are so important to the nuclear physicist; the huge industrial processing plants that provide the scientist as well as the consumer with materials never available in past times; and, the modern rocket.

Thus it is that science and engineering advance together in a powerful partnership. Today, we see this partnership stronger than ever in the space program. Because of the modern rocket, the scientist is now able to send his research instruments into the high atmosphere and out into space where they can make measurements that were hitherto impossible at the surface of the earth. Eventually man himself will go along with his instruments to the moon and into deep space to continue the scientific investigation of space and to lay the groundwork for what may be termed "space engineering." In the meantime, unmanned satellites and space probes are gathering basic scientific data that are also needed in the development of manned space flight.

At this point a historical note may be of interest. Robert Goddard, who is known as the father of modern rocketry, was actually a physicist rather than an engineer. He was interested in learning more about the earth's upper atmosphere than was possible with earth-based or balloon-borne instruments. Thus motivated, he developed with remarkable accuracy and thoroughness the theory of the rocket, and then set about to engineer it. Likewise, many of the German scientists who worked on the first big rockets like the V–2 were motivated by an interest in travel through space.

With the availability of the modern rocket, science in space, or space science as it is called for brevity, has become a reality. Space science calls upon a broad range of disciplines to attack some of the most important and challenging scientific problems today. Among these problems are the investigation of the earth and sun, moon and planets, stars and galaxies, and life in space, from the vantage point provided by the orbiting satellite or the deep space probe.

Some of the disciplines involved in space science are as follows: physics, chemistry, astronomy, astrophysics, geodesy, meteorology, geology, geophysics, geochemistry, mathematics, biology, biophysics, biochemistry, seismology. The list is a long one. More interesting, however, than the large number of disciplines involved in space science is the partnership that is required among these disciplines. Out in space, nature makes it plain that the division of science into the many disciplines is a human convention, and is one that must be forgone if real progress is to be made in understanding the many phenomena in space. For example, the investigation of the earth and the sun and the interplanetary medium calls upon the astronomer, physicist, and geophysicist to move ahead together in a closely integrated partnership.

EARTH AND SUN

Satellites and sounding rockets afford the scientist with a very powerful means of investigating the earth on which we live. Equipment can be sent aloft to investigate the atmosphere at all heights, and to study the ionosphere which lies in the upper reaches of the atmosphere and consists of large numbers of electrons and ions. The atmosphere is important because it comprises the source and substance of our everyday weather. The ionosphere is important because it furnishes the means by which radio waves may be reflected beyond the horizon, thereby making it possible to communicate around the world.

Only a few decades ago, many textbooks referred to the upper atmosphere as a rather quiet medium in which the various gases separated according to their relative weights, giving the atmosphere a stratified character. Indeed, it was this belief that led to the term "stratosphere" which is well-known today, but which in the lower portions of the atmosphere is completely a misnomer.

Satellites and sounding rockets, extending ground-based observations by means of radio and other techniques, have shown that the upper atmosphere is far from quiet. Instead, the upper atmosphere is an exceedingly complex medium, subject to gross and sudden changes dependent on activity on the sun. Large temperature changes occur between day and night, and between sunspot maximum and sunspot minimum. The composition and ionization is affected and controlled by solar electromagnetic and particle radiations.

Although the lower portion of the atmosphere below about 100 kilometers is thoroughly mixed and turbulent, the upper reaches are now known to be quite different in composition. As shown in figure 1, the lower portions of the atmosphere give way to a region in which atomic oxygen predominates, which in turn merges into a region where helium is the dominant constituent, which finally merges with a region in which hydrogen is the predominant constituent.

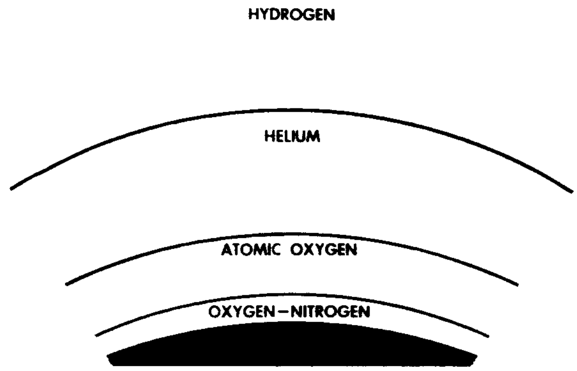


FIGURE 1.—Atmosphere composition.

The hydrogen layer merges with interplanetary space through what has come to be known as the earth's magnetosphere. (See fig. 2.) The earth's magnetic field serves to trap charged particles, primarily electrons and protons, in a region extending out from 10 to at least 20 earth radii from the surface of the earth. At an altitude of about 1 earth radius, the density of the earth's atmosphere becomes equal to that of the interplanetary gas. One would, therefore, expect this to mark the boundary of our atmosphere. The presence of the magnetosphere, however, serves to extend the earth's atmosphere far out into space in a sort of terrestrial halo that has come to be known as the Van Allen Radiation Belts.

Satellite-borne instruments plot out the earth's magnetic field and measure the radiations to be found in these Van Allen Belts. They likewise provide a new line of attack on the auroras which have hitherto had to be studied from observatories on the ground.

One can also use satellites to study the interior of the earth. Observations on the influence of the earth's shape and mass distribution on the orbit of the satellite enable the scientist to determine the strength of the earth's interior and to measure the distribution of matter within the earth. Such measurements have been made by means of the first Vanguard satellite and a number of the Explorers.

Observatories above the earth's atmosphere make it possible to investigate the sun and its activity (see fig. 3) with a thoroughness not possible from the ground. The ultraviolet, X-ray, radio, and infrared radiations that do not reach the ground can be observed and measured from space platforms. Sunspots, solar flares and solar storms, electromagnetic radiations from the sun, the solar corona, and clouds

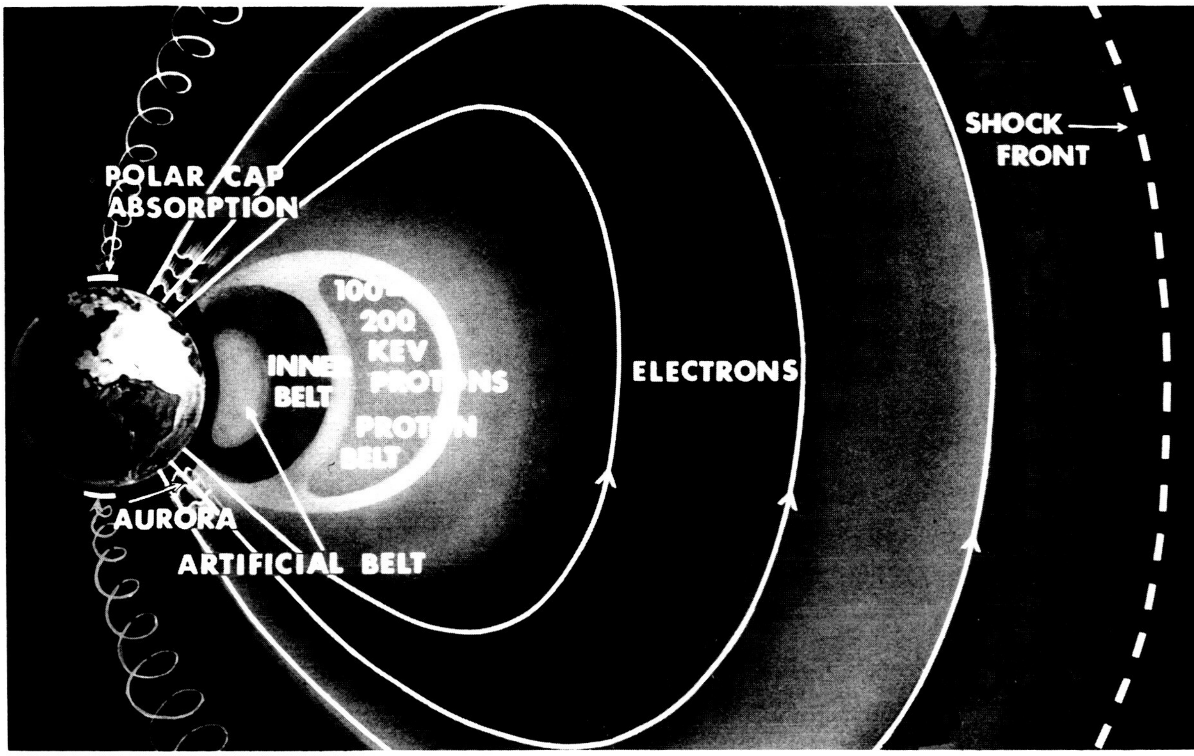


FIGURE 2.—Magnetosphere.

of energetic particles expelled from the solar surface are all amenable to investigation by means of satellite-borne and space-probe-borne instruments.

The first Orbiting Solar Observatory, OSO I, was launched on March 7, 1962. In the first 8 months of its operation, this Observatory provided the scientist with thousands of times more ultraviolet and X-ray data than had been obtainable hitherto using sounding rockets. Even today, OSO I continues to operate, although in limited fashion, returning usable scientific data to the scientist on the ground. These detailed studies of the sun are important in developing an understanding of solar flares and other solar activities that discharge particles and magnetic fields into the interplanetary medium.

The interplanetary medium (see fig. 3) must be understood before we commit men to long trips out to the moon or planets. This medium consists normally of 5 to 15 particles per cubic centimeter at our distance from the sun. It is through this interplanetary medium that the sun dispatches solar cosmic rays toward the earth, which are hazardous and may even be lethal to crews and components of spacecraft.

The interplanetary medium is the region through which the sun exerts its influence on the earth, giving rise to our weather, creating the ionosphere and the auroras, stirring up the radiation belts and causing magnetic storms, and at times completely disrupting radio communications on the surface of the earth.

Because of Explorer satellites, Pioneers, especially Pioneer V, and Mariner II, the interplanetary medium is no longer the complete mystery that it once was. Nevertheless, there is much yet to be learned about it, and the NASA program includes a vigorous plan of attack on the problems of understanding interplanetary space and the role it plays in transmitting solar influences to the earth. To the scientist, this interplanetary space appears as a gigantic laboratory affording the opportunity to investigate matter and magnetic fields under conditions of low density that are absolutely unobtainable in the laboratory.

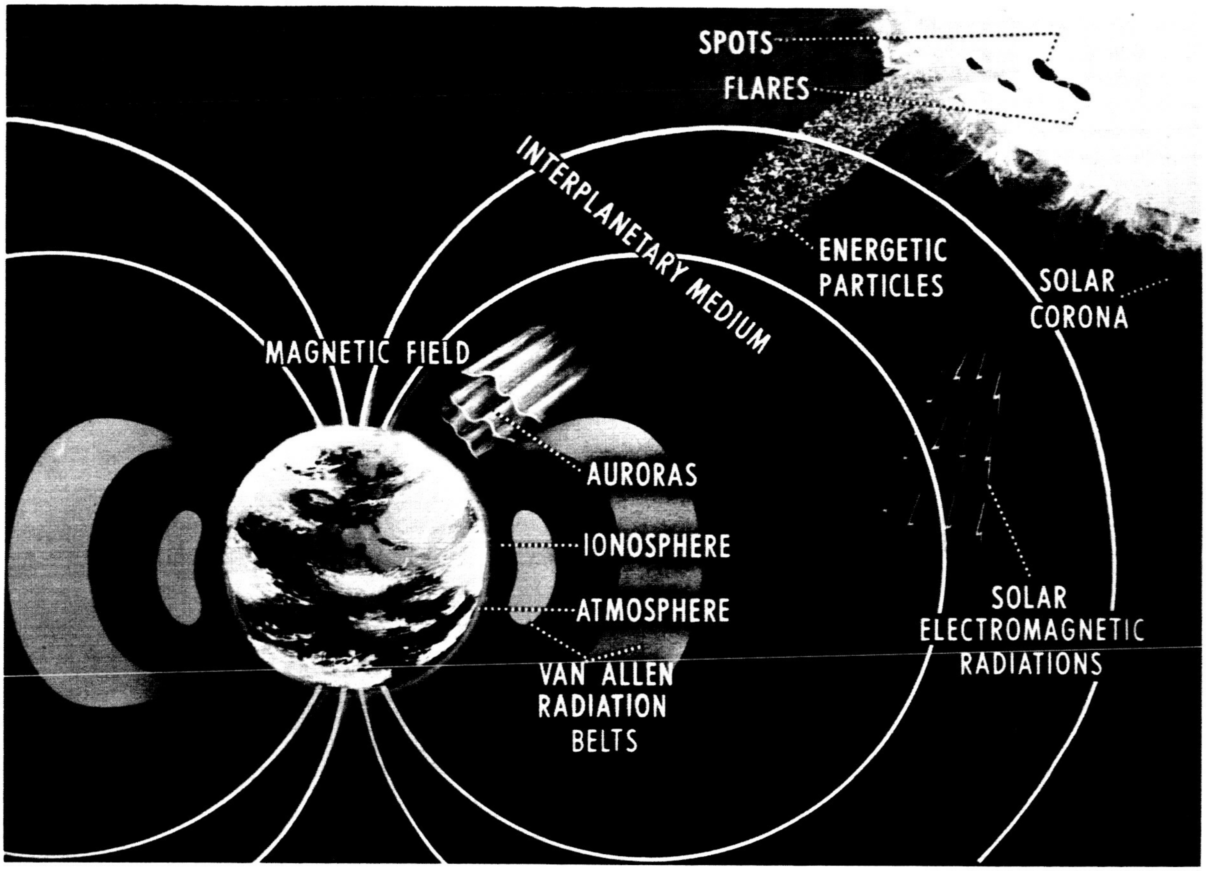


FIGURE 3.—Earth and sun.

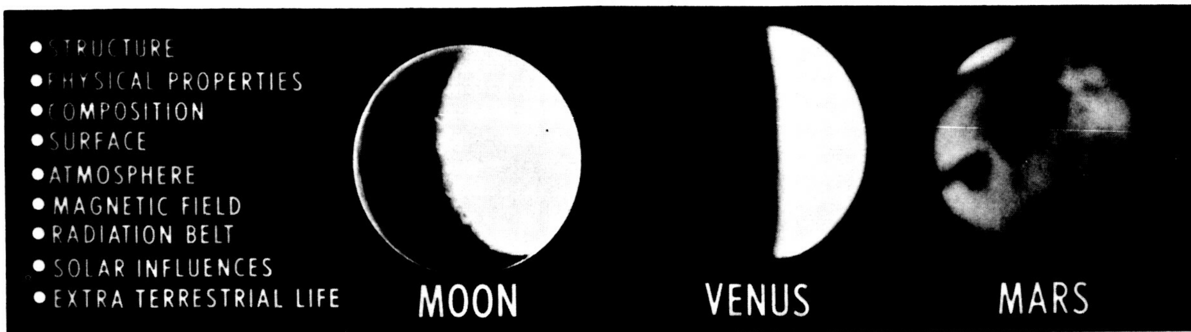
MOON AND PLANETS

The moon offers all kinds of scientific and engineering opportunities (see fig. 4). As the target of our manned lunar landing program, it brings to focus an engineering effort that exceeds in scope and daring all previous engineering ventures of mankind.

In the field of science, the moon is of particular interest because it may furnish one of the most significant clues to the question of how the earth and other planets of the solar system originated. The lunar surface is likely to have preserved the record of past events going back billions of years, perhaps nearly to the time of its origin 4½ billion years ago. This record has remained unmarred by the erosion of atmospheres and oceans, and from the appearance of the moon as seen through telescopes, has been unchanged by mountain-building processes. On the earth, and probably also on Mars and Venus, the surface record is lost because of these atmospheric and mountain-building processes.

Mariner has opened up the field of planetary sciences for the United States, as Lunik has already done for the U.S.S.R. in lunar investigations. The opportunities that lie ahead will be of interest to many disciplines in addition to astronomy, but should be especially attractive to the geophysicist. Most of the techniques that will be required to observe and make measurements on these bodies will be those of the geophysicist. Most of the instruments will be adaptations of geophysical instruments, and the scientists who press forward with these lunar and planetary investigations will be, in effect, geophysicists whether or not they call themselves such.

These forthcoming opportunities not only extend the range of the geophysicist's investigations to other planets, but also broaden the perspective in which he can view the earth.



	MOON	VENUS	MARS
DIAMETER	2,162 MILES	7,800 MILES	4,215 MILES
SURFACE GRAVITY RELATIVE TO EARTH	0.16	0.85	0.38
TEMPERATURE	212° F FULL MOON -243° F DARK SIDE	ABOVE CLOUDS: 110° F SURFACE: 570° F	-15° F SURFACE
ATMOSPHERES OF PRESSURE AT SURFACE	ESSENTIALLY ZERO	2 ?	1/10
ATMOSPHERIC COMPOSITION	?	CARBON DIOXIDE WATER VAPOR? NITROGEN?	CARBON DIOXIDE WATER VAPOR? NITROGEN?

• COMPARATIVE STUDIES
• HISTORY

FIGURE 4.—Moon and planets.

Comparative investigations of earth, moon, and planets will contribute greatly to the understanding of each one; and also to the understanding of the whole solar system.

STARS AND GALAXIES

As the oldest of the sciences, astronomy has had an illustrious history. From ground-based observations that have been limited to the very narrow range of wavelengths in the visible portion of the spectrum, plus small extensions into the ultraviolet and the infrared, the astronomer has put together a truly remarkable body of astronomical knowledge and theory. More recently the huge radio telescope has permitted observations in the radio wavelength portion of the spectrum.

Nevertheless, astronomical theory itself indicates that the limitation of observation to the visible and part of the radio portions of the spectrum is a very serious limitation indeed. According to theory the most fundamental processes in the birth of stars can be observed only in the infrared, while the most exciting portions of the evolution of the star are observable only in the ultraviolet. For this reason, the satellite orbiting above the earth's atmosphere opens up exciting new opportunities to the astronomer.

One of the most important programs in NASA involves the Orbiting Astronomical Observatory, designed to exploit these new opportunities in astronomy. Carrying instruments and telescopes above the earth's atmosphere, OAO will permit observations in all parts of the spectrum. The importance of being able to do this is illustrated in some measure by the inset in the lower right corner of figure 5. Here the same object, the Crab Nebula, is shown photographed in blue, yellow, red, and infrared wavelengths. The differences are quite apparent, but actually are much less marked than differences to be observed when observa-

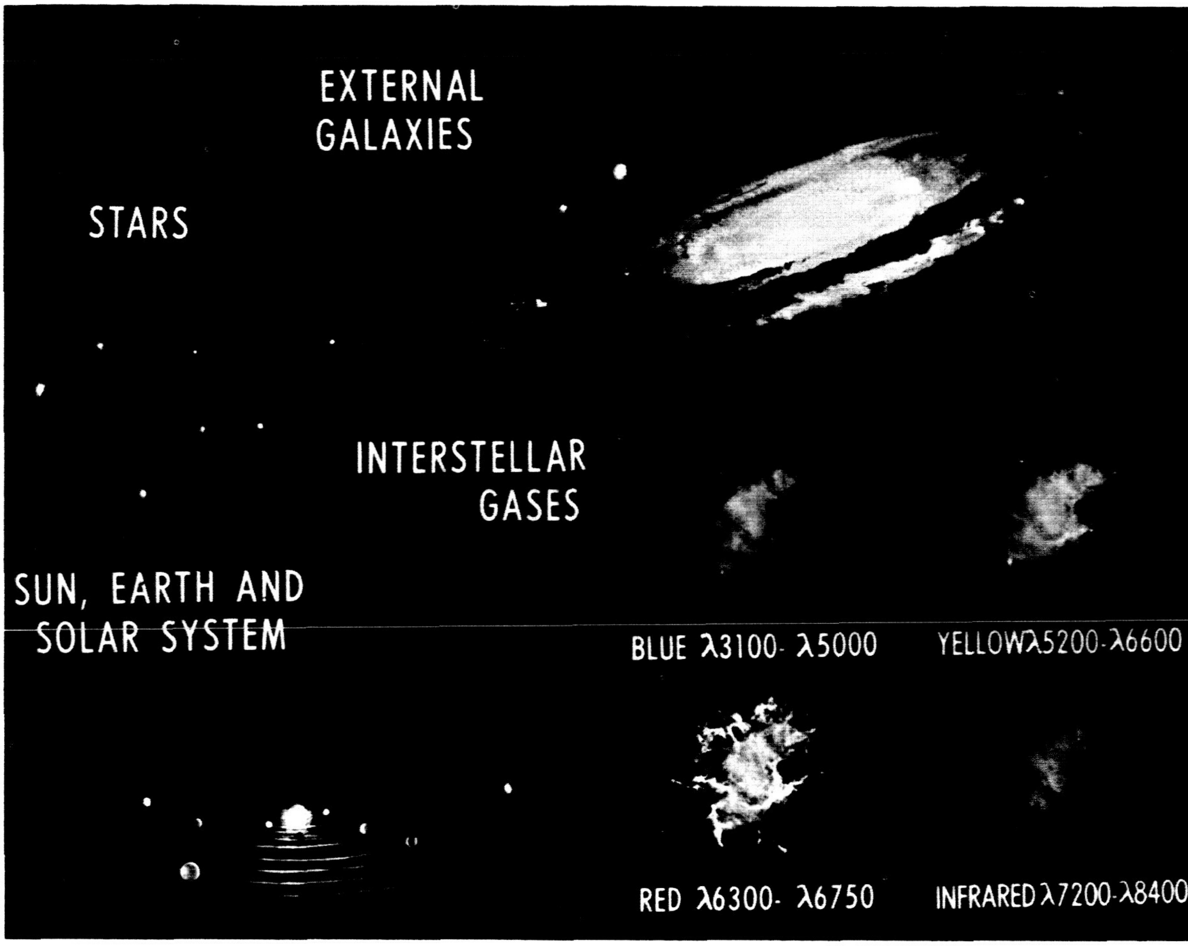


FIGURE 5.—Stars and galaxies.

tions are made in the ultraviolet and X-ray wavelengths.

An additional new opportunity available to the astronomer is that of observing bodies of the solar system at close range. The lunar and planetary probes provide this opportunity for the planets of the solar system. In the course of time, probes directed to the vicinity of the sun itself will permit extremely valuable close-at-hand observations of our nearest star.

Still a third opportunity open to the astronomer and cosmologist is that of being able to perform experiments on a scale utterly unobtainable on the surface of the earth. By using spacecraft in satellite orbits about the earth or on escape trajectories from the earth, controlled or semicontrolled experiments can be performed on relativity, gravity, celestial mechanics, galactic cosmic rays (the origin of which is still unexplained) and other topics which will add grist to the cosmologist's and cosmogonist's mill.

LIFE IN SPACE

Certainly one of the most exciting possibilities in space exploration is that indigenous life may be found outside the earth. The most likely candidate is Mars, where balloon observations in the infrared have detected emissions characteristic of the carbon-hydrogen bonds. While this does not prove the existence of life on Mars, it is most certainly highly provocative. For this reason, preparations are going forward with various types of instruments to search for living forms on the Red Planet. These will be carried in fly-bys and landers as soon as the necessary transportation is available.

All data available at present would indicate that there is little likelihood of life on Venus. Various radio astronomical observations of the planet indicate that the surface temperatures are in the vicinity of 700° K, well over the boiling point of water. These temperatures have been confirmed by the recent results from Mariner II. Taken in conjunction with the probably very high pressures existing on Venus, exceeding 20 atmospheres at the surface, such temperatures indicate that the entire planetary surface must be bathed in a searing atmosphere and that there is no chance of life there. The biologists insist, however, that there may yet be life on Venus, existing in the cooler upper atmosphere. Balloon samplings are being made of the earth's upper atmosphere to search for organisms that might be living there. Results from these investigations have already shown that there are such organisms living in the earth's upper atmosphere. These investigations may shed additional light on how much of a point the biologists have in connection with Venus.

It does not appear likely that there are living forms on the surface of the moon, because of the lack of an atmosphere, the lack of any observable water, the extreme temperature ranges to which the lunar surface is subjected, and the constant bombardment of the surface by highly energetic electromagnetic and particle radiations. Some scientists believe, however, that there might be living forms existing at some distance below the hostile lunar surface.

At any rate, it is clear that we must be very careful about what we do in the case of Mars. It is NASA policy, in the investigation of Mars, to protect by all possible means the opportunity that Mars may present to study nonterrestrial life forms. This includes sterilizing any space probes that are sent to Mars so as to prevent infection and contamination of the planet with terrestrial life forms and materials.

If the planet Mars is to be maintained as an ecological preserve, this can be done only by international cooperation. At the present time, this means specifically cooperation between the U.S. and the U.S.S.R.

In the case of the moon, we shall take advantage of the hostility of the lunar surface to assist us in protecting the biological opportunities that may exist there. Lunar spacecraft, although not absolutely sterile, will be maintained at operating-room cleanliness. Whatever organisms remaining on the spacecraft do land on the moon will then be prevented by nature itself from spreading. Thus, the hostility of the lunar surface will then be relied on to prevent any spread of infection, and, indeed, to sterilize the landed object in the course of time.

It may well be that there is no extraterrestrial life to be discovered in the solar system. Nevertheless, that does not end our interest in life in space, because we, ourselves, are certainly going to put life out there. Indeed, we have already begun to do this in our Mercury program, as the Russians have in their Vostok program. Thus, one very important aspect of life in space concerns the influence of the space environment and space flight environment on terrestrial organisms.

In satellites and space probes, there will be the opportunity to study the effects of weightlessness, radiation, new periodicities, and other conditions strange to terrestrial life. Man himself will be one of the major objects of study

THE ENVIRONMENT OF SPACE

The scientific investigation of space, the effort to develop practical applications of space knowledge and technology, and the program to develop the ability of man to fly through space all direct attention to the environment of space as one of the most important of space phenomena. There are at least two aspects of our investigations of space environment: first, the scientist's desire to get the whole picture; and, second, the engineer's need to know what men and equipment are encountering when they go out into space.

Although their motivations may be different, the scientist and the engineer need to know the same things. Solar wind, plasmas in space, cosmic rays, the interplanetary magnetic field, solar fields, solar flares and particle eruptions, and planetary fields must be known to the scientist in detail in order that he can work out a theory of what is happening. The same quantities must be known to the engineer who is concerned with the protection of both equipment and crews against the hostility of the space environment.

The scientist wishes to know about the physical, chemical, and thermal properties of the moon, not only out of general scientific curiosity, but also in order to gain insight into the broader problem of the origin of the solar system. The engineer, designing equipment and planning operations for landing men on the moon, needs to know these same quantities to get his job done. The scientist seeks to determine the structure of the gravitational fields of the earth and the moon as one of the most important properties of these bodies and as still another approach to the study of their origin and history. The engineer needs these data in working out the trajectories and rendezvous maneuvers for space flight. These examples could be continued at length.

It is clear that, here again, we see an example of the close partnership between engineering and science. Both progress together, and as each does his job, the other is benefited.

ENGINEERING IN SPACE

Having returned at this point quite naturally to the partnership between science and engineering, it may be well to devote a little attention to some of the future engineering accomplishments that inevitably will contribute to the doing of science in space—the matter of engineering in space.

When man has developed the ability to fly through space and to move about in space, he will be in a position not only to carry forward the scientific exploration and investigation of space, but also to undertake engineering tasks. This matter of engineering in space is still a thing of the future. At the present time, space engineering is carried out on the ground. The engineered object, if it is a space vehicle, or a spacecraft, is placed in orbit after the engineering has been accomplished.

But one day, the engineer will go out into space to do part of his work there. One can foresee the need to assemble in space large laboratories and stations to serve as staging areas for interplanetary flight.

It may be necessary to form the reflecting surfaces for astronomical telescopes under the conditions of weightlessness under which they are to operate so as to eliminate distortions that would be introduced by forming them on the ground under normal gravity and then launching them into the weightless conditions in orbit.

Considering the tremendous expense that one must anticipate for the construction of huge orbiting observatories and laboratories of the future, it may well prove to be far cheaper to provide human maintenance and repair than to rebuild and launch a new satellite every time an old one has ceased to function. In addition, it may be possible to update a very expensive facility by replacing some of the equipment and instrumentation with improved devices.

The time will come when man will do engineering on the moon, and, in the more distant future, on the planets. In both cases, his engineering will be done under conditions far different from those he encounters on the earth. In the case of the moon, for example, the gravity will be only one-sixth of that met with on the earth, while the lack of an atmosphere, bombardment by meteoritic particles, the constant presence of the interplanetary radiations, the tremendous range of temperatures, the possible presence of dust that may be more than just a nuisance, unusual conditions of electrostatic charging, and so forth, will confront him with problems that will tax his ingenuity and skill to the utmost.

Engineering in space also will have value in the development of both civilian and military applications of space. Indeed, in many ways the ability to engineer in space will influence our living at the surface of the earth. Some of these benefits are doubtless unforeseen at the present time.

SPACE SCIENCE PROGRAM SUMMARY

In figure 6 are shown the NASA scientific satellites launched from 1959 through 1962. Several important observations may be drawn from this chart. In 1962, we had 100 percent successes with our scientific satellites, whereas prior to 1962, the successes did not exceed 50 percent in any year. This dramatic improvement is due to two factors: first, we have learned how to design and develop reliable

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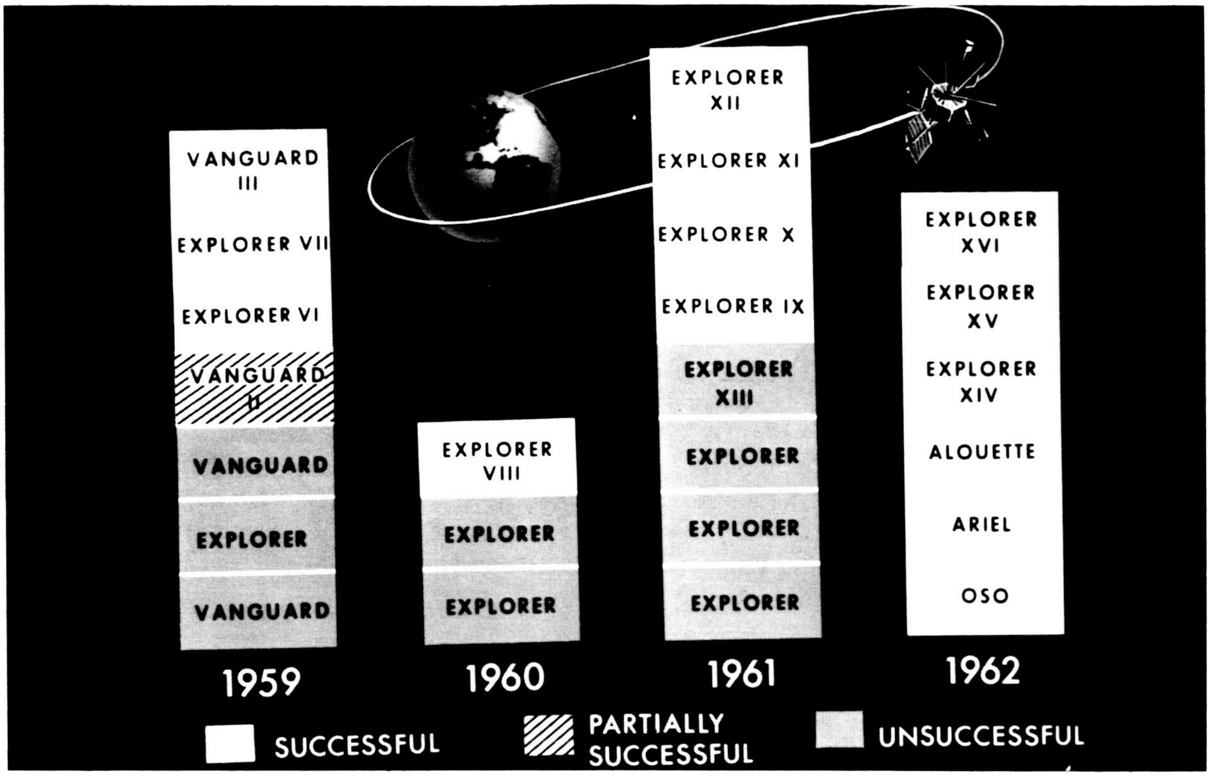

FIGURE 6.—Scientific satellites.

spin-stabilized satellites; second, we have capitalized on launch vehicles for satellite injection which are highly reliable, such as the Thor-Delta.

Another observation to be made is that the nature of our satellite missions has changed. In 1962, we flew our first solar observatory, which heralded a new era of astronomical observation. In addition, 1962 saw the successful commencement of a cooperative flight program for space exploration with Canada and England as part of a broad program of international cooperation. The Ariel satellite was instrumented by British scientists, and the Alouette satellite was developed entirely by the Canadians.

In the area of space probes we are at a development stage comparable with that of scientific satellites in previous years. As indicated in figure 7, we attempted five lunar and planetary missions in 1962. Of these five, only one mission can be counted a complete scientific success. This was the Mariner II which, on December 14, 1962, made history by flying on a predetermined trajectory close to the planet Venus. Suffice it to point out here that these space probes have called upon the most advanced technology in launch vehicles and unmanned spacecraft this country has yet attempted. Initial development problems have been encountered, both with the launch vehicles and the spacecraft, and strenuous efforts are underway to solve these problems.

Figure 8 summarizes the history of sounding rocket launches in this country since 1956. The activity was very high during the period of the International Geophysical Year, that is, 1957–58, following which launchings dropped off markedly. Since 1959, however, the activity has built up steadily and it is important that this buildup continue. One of the prime reasons for the dramatic success and high reliability we enjoy in the scientific satellite field is the fact that as many instruments and components of our satellites as can be accommodated are tested on sounding rockets before they are committed to the more expensive satellite programs.

Figure 9 shows the scheduled activity for our

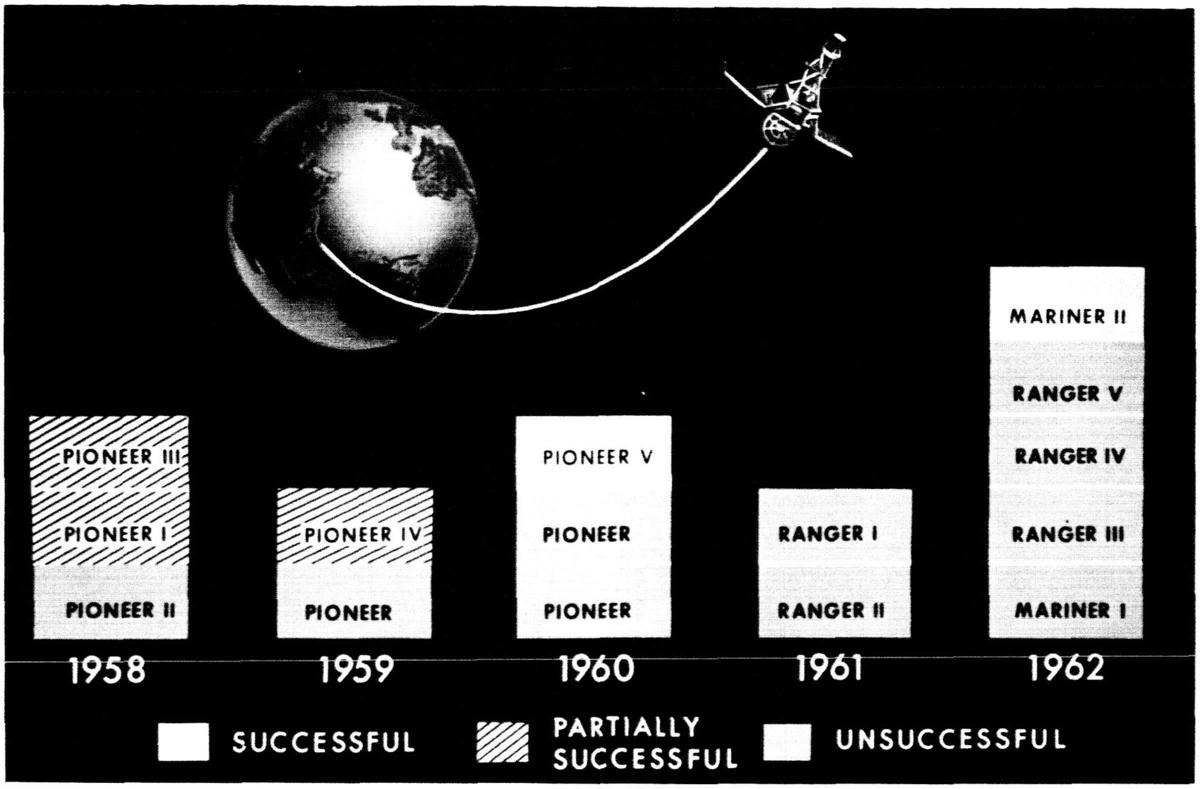

FIGURE 7.—Deep space probe.

Geophysics and Astronomy Programs. The explorers and monitors, and the international satellites, programs which have been very active in 1962, are planned to continue at about the same rate throughout the time period shown in this chart. Sounding rocket activity will increase. In addition, it is planned to continue our launchings of the highly successful Orbiting Solar Observatories at two a year until 1966 or 1967, at which time the rate should increase to about four a year. Significantly, this increased launching rate in the 1967 time period coincides with the advent of maximum solar activity. The first use of an OSO with increased observational capability will occur at this time. Much of our effort during the past year in the area of Geophysics and Astronomy has been directed toward the development of two large observatories—the Orbiting Geophysical Observatory and the Orbiting Astronomical Observatory. The Geophysical Observatory will make its first flight in 1963. It is planned for launch rates of approximately three per year thereafter, covering two important orbits with well-integrated payloads of 20 or more advanced experiments. The Astronomical Observatory will not be flown until 1965 and will continue at approximately 9-month intervals. This satellite will constitute a major milestone in the science of astronomy.

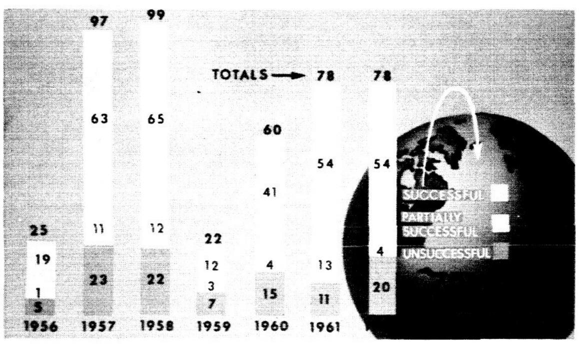

FIGURE 8.—Sounding rockets. Firings by calendar year.

Turning now to the Lunar and Planetary Programs, as illustrated in figure 10, we see that our current active flight projects are Ranger and Mariner. Ranger has had five launchings to date. This project, which is de-

CALENDAR YEAR

	1962	1963	1964	1965	1966	1967
SOLAR OBSERVATORIES	1	1	2	2	3	4
ASTRONOMICAL OBSERVATORIES				2	1	2
GEOPHYSICAL OBSERVATORIES		1	3	3	2	3
EXPLORERS & MONITORS	3	5	5	5	5	5
INTERNATIONAL SATELLITES	2	2	5	2	2	2
SOUNDING ROCKETS	78	90	110	130	140	145

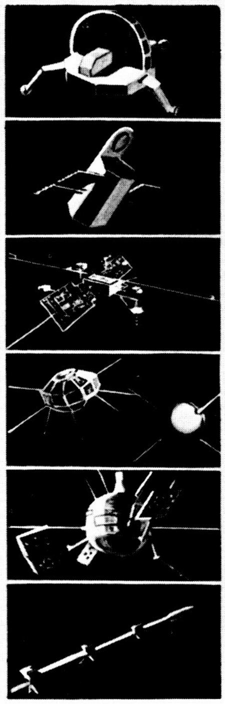

FIGURE 9.—Geophysics and Astronomy programs.

CALENDAR YEAR

	1962	1963	1964	1965	1966	1967
RANGER	3	1	6	6	6	
SURVEYOR			2	6	8	8
MARINER	2	0	2	4	5	5
PIONEER			1	3	4	3

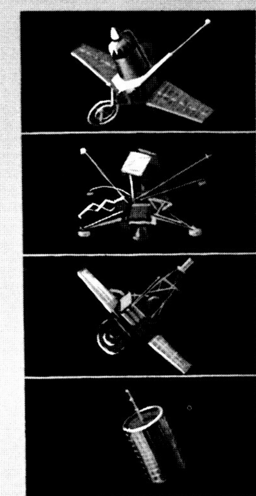

FIGURE 10.—Lunar and Planetary programs.

signed to obtain our first detailed information about the lunar surface by means of approach photography and landing capsules, has resulted in many technological developments and an impact on the lunar surface. Following a series of improvements, Ranger will continue on into 1966. The Ranger will be followed by a considerably more advanced spacecraft, the Surveyor. The Surveyor will commence its test flights in 1964 and should result in an instrumented soft landing on the moon in 1965. In addition, an orbiting version of the Surveyor—or some orbiter, not necessarily the Surveyor—is planned for late 1965 or early 1966. This team of spacecraft, the Surveyor lander and orbiter, will provide us with our most extensive knowledge about the moon prior to manned landing, and will probably be utilized well beyond the first manned mission.

In the planetary program, our active flights began with the highly successful Mariner in 1962 and will pick up again in late 1964 with the next opportunities to fly to Mars. Beyond 1964, it is planned to launch a minimum of two flights at each opportunity for the Mars and Venus missions. The Mariner series, which began with the capability of observing a planet during close fly-by, will culminate with the landing of instrumented capsules on the planetary surfaces.

Exploration of the planets constitutes what may be the next greatest national challenge in space beyond manned exploration of the moon. Accordingly, planning is continuing toward a large spacecraft to make use of the Saturn launch vehicle capabilities. This project, known as Project Voyager, will be continued into preliminary design studies in 1964.

The Pioneer series of flights is a recent addition to our program. This project is designated to capitalize on the high reliability of the Thor-Delta launch vehicle and the simplicity of a light spinning spacecraft reminiscent of the successful Pioneer V. The Pioneer program will provide a series of deep space probes in the 1964 through 1967 time period which will help us monitor solar radiations, both as a contribution to the International Quiet Sun Year and in preparation for solar flare prediction at the time of the manned lunar mission.

The Bioscience Flight Program is shown in figure 11. This program which was in its formulative stages last year, is now beginning to accelerate. In the upper part of figure 11, our balloon-borne program is illustrated. This program is currently concentrating on two objectives: the first of these is to obtain biological samples from the upper stratosphere, and the second is to obtain infrared spectra of the planets by carrying a telescope to high altitudes for observations of Mars and Venus. In addition, the Biosciences Flight Program is entering into the satellite flight phase. In late 1964, it is planned to launch the first of a series of recoverable satellites which will carry multiple experiments in fundamental biology. Beyond these early exploratory flights, we are planning eventually to use manned spacecraft for the conduct of biological experiments in space.

In addition to the sounding rockets required to carry on the rocket sounding portion of the program, space science flights will be made with Scout, Delta, Thor-Agena, Atlas-Agena, and the Atlas-Centaur. In addition, looking forward to the more advanced planetary missions, we are examining closely the use of the Saturn launch vehicle series.

SPACE PHENOMENA ON EARTH

The space program, itself, constitutes one of the most fascinating and significant of space phenomena. It involves or gives rise to a variety of activities and effects, some of them very complicated and far-reaching, which may be described as space phenomena on earth. Among these may be listed:

- The impact of space on education
- The economic impact of the space program
- The social impact of the space program
- The cultural impact of the space program
- The political impact of the space program
- International cooperation

The very existence of a broad space program may well provide some of the means for accomplishing objectives in regional growth and development, which certainly involve the first five topics listed.

In the last topic listed, we already have demonstrated proof of the far-reaching consequences of the space program. Through inter-

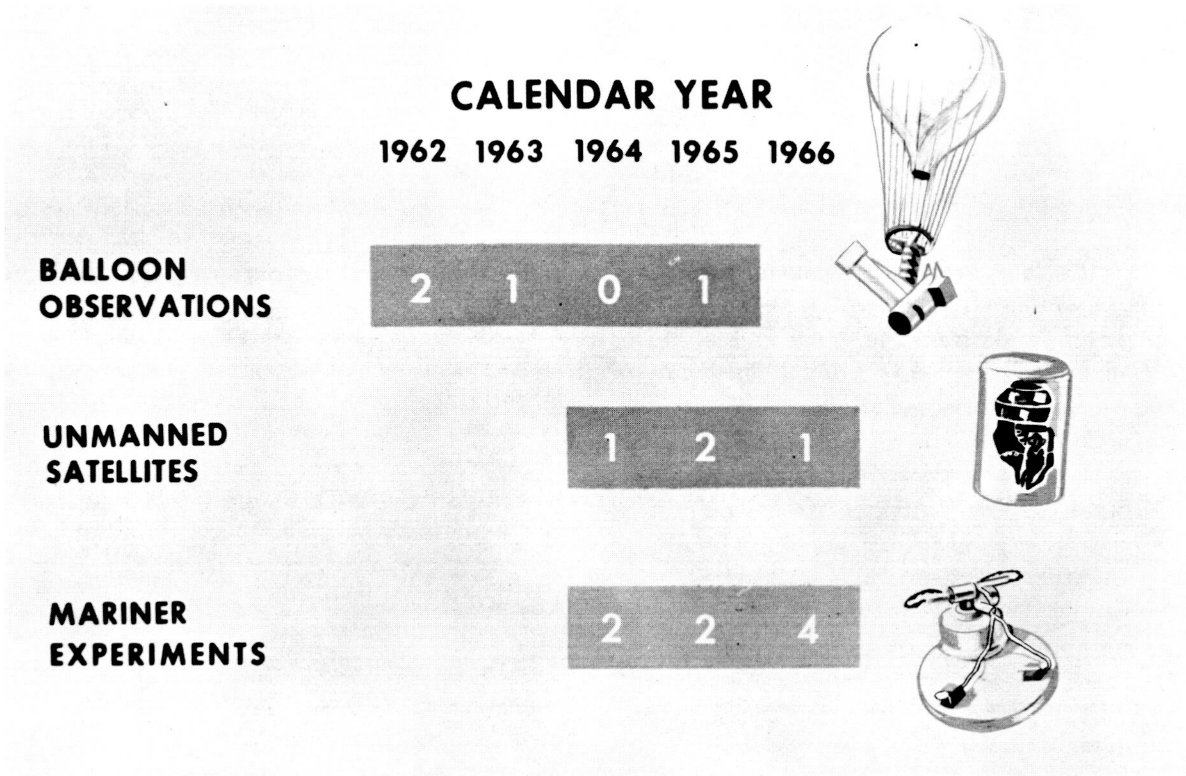

FIGURE 11.—Bioscience program.

national cooperation in space, there are many countries that have found that the existence of a NASA program has assisted them in developing space or space-related programs of their own. In this, I do not refer to those efforts of direct assistance to the U.S. space program, in which countries have made available land on which U.S. tracking stations may be erected, or in which the countries themselves participate in the tracking of our unmanned and manned spacecraft. These are, indeed, important elements of the space program, and of great value and assistance to the United States. However, I wish to turn attention to the space efforts of other countries that have developed by virtue of the existence of the U.S. program.

Because of the U.S. program, Canada was able to build an entire satellite using its own resources and personnel, and have it launched on a U.S. rocket. Similarly, the United Kingdom has been able to instrument a satellite that was provided by the United States and then launched on a Delta rocket. Italy has found it possible to initiate a satellite program based on the Scout rocket as the launch vehicle. Also, in the sounding rocket area, many countries, including Sweden, Italy, Pakistan, and India, for example, have found it possible to undertake programs of their own because of cooperation growing out of U.S. interest in what these other countries are attempting to do.

It should be emphasized that these programs are not little U.S. programs established in other countries through the use of our funds. Quite the contrary. These are genuine national programs, in which there is no exchange of funds between the United States and the cooperating country. Other countries, because launching services may be available, or sounding rockets or special instrumentations may be provided, have found it possible to develop their own activities, funded by themselves, and carried out by their own scientists and engineers. This type of cooperation permits the other countries to develop their own capabilities, and provides a maximum of benefit to them. At the same time, since the scientific results are made generally available through open publication in the scientific literature, we also benefit.

It is hoped that in some way, through direct or indirect association with the NASA program, community leaders will find some means for solving urban problems. Whatever success is achieved on a regional basis will benefit not only that region but also the space program, and the entire Nation as well.

Chairman: **C. Easton Rothwell**
President, Mills College

IS OUR SCIENTIFIC RESEARCH SERVING THE NEEDS OF THE NATION?

George P. Miller

GEORGE P. MILLER, U.S. House of Representatives, 8th District, California; Chairman, House Committee on Science and Astronautics. Formerly: California State Assemblyman; Executive Secretary, California Division of Fish and Game; Professional Civil Engineer. St. Marys College (BS, LLD).

IT WOULD BE entirely pretentious for me to identify and describe in specific detail research problems that are of vital importance to our country. But I think it is certainly quite possible to identify, in terms of human needs, some pressing problems that deserve much more attention from the scientific community than they are presently receiving.

I hope that all will agree that the eventual satisfaction of human needs, both philosophical and material, is the ultimate end of all science, research, and technology. I include technology here solely to emphasize the fact that it is through technology that scientific knowledge most often can be translated into goods or power.

I would like to address a few comments regarding the word "need." No doubt there are as many different interpretations of that word as there are points of view. Every facet of our society that depends more or less upon science and engineering for its continued existence contributes to the overall demand for new research products. Hence, the research needs of this country can be best understood or analyzed in terms of the effect—the stimulus to respond thereby injected into our scientific community.

The National Academy of Sciences has estimated recently that a total of $17.8 billion was spent by the Federal Government and private industry for research and development during 1962. It is quite apparent to me that regardless of whether private or public money was spent, the expenditure of $17.8 billion was hardly done at random. It is obvious that funding of such scope had to be directed toward acquiring specific knowledge to satisfy specific needs, or for exploration to determine what our research products will be in the foreseeable future.

No one will question that this era, these unprecedented times of truly global conflicts and convulsive expressions of surging nationalism, will be known as the Age of Science and Technology. This will be the label of the historian who neatly divides the past into tidy categories.

But we are not blessed with a historical view of the present; our full course has not yet been run. We can only look at the wealth we hold in our hands, the riches that surround us, and then decide whether science and technology has up to now fulfilled all our needs.

We are housed better, fed better with more variety, clothed better, and entertained more than any other people in the history of mankind.

We have unprecedented means of communications. We have at our command industrial power and energy that exceed those of any other nation on earth.

Our society has been made far more antiseptic through medical research than any other, and hence our productive lives have been prolonged. We have, through applied research, achieved greater leisure than has ever been known before by so many.

Have science and technology satisfied our needs? If you limit them to food, clothing, shelter, and security, then of course—far beyond any expectation.

I am tempted to say that science, engineering, and technology actually are and have been preoccupied as much with our desires as with our needs. I admit to a certain uneasiness, however, when I contemplate all that we have. Have we really achieved material security? Are all our symbols of wealth and well-being true indicators of our national strength?

Will our future vigor, security, and advancement as a people be assured by the use we are now making of our science and technology? Or have we built for ourselves, through research and its applications, a lotus land where we have become so preoccupied with enhancing our own material well-being, our national ego, that the human ills of the rest of the world tend to become remote and unreal?

The people of this world have always been generally divided between the "haves" and the "have-nots." All conflicts between peoples are directly or indirectly rooted in this division. It lies at the original foundation of the causes for the ideological clash of today, of state control versus private enterprise, communism versus free society.

In all ages, including our own, the have-nots have far outnumbered the haves. The advancement of technology of other eras, as primitive as it may seem now, made possible the isolated development of culture and civilization out of a sea of barbarism.

It seems tragically paradoxical that the results of that very same technological advancement seem often to have led to gross national self-indulgence, to have insulated eventually a relatively few people from the harsh and unequivocal facts of life and death that confront the rest of mankind. And it has been the hungry, the homeless, and the harried who have been the witnesses, often the agents, of the downfall and the destruction of empires.

Thus, the fact today of more than a billion illiterate people must have some meaning for us. The fact that more than half the peoples of the world exist on diets significantly below minimum standards for good health must have some import to our future. The fact that insurance statistics assign to us an average longevity of 65 years or more as opposed to less than 30 for substantial portions of the world population cannot be dismissed as none of our concern.

We dare not ignore historical precedent—not if we look beyond the period immediately ahead of us to the next 25 years or beyond. Just consider the nature of the world we live in today. One part is divided into two hostile armed camps, the other composed of impotent but watchful bystanders who expect to become eventually the beneficiaries of the East-West conflict, no matter the outcome. The Soviet Union and Communist China, both of which came into being out of the desperation of millions of hopeless, destitute people, are on the march. There is no doubt about the single-mindedness of their objective to acquire in any way expedient as much as possible of the world's goods and power. Their assault upon the West will continue to receive a major impetus from the clamor of their people for a better life. And there are many, many sympathetic ears elsewhere in the world who are not unmoved or indifferent to what they hear.

The point is this: I think one of the most pressing needs of America is the application of its scientific research and development resources to the solution of the human problems that weigh the human balance scale opposite ourselves, that contain within them the possible threat of our destruction.

The United States has for many years poured out tremendous resources to build and strengthen the economies of nations all over the world in order to eliminate breeding grounds of communism and to create political stability. Since 1946, we have sent abroad more than $100 billion in the form of all types of assistance. This is in addition to the beneficial impact of expenditures for such joint efforts as UNESCO, NATO, SEATO, and our own military establishments. Our dollars and resources have been the major factor in the rebuilding of Europe and Japan. We have helped nation after nation, new and old, in every part of the world to survive the economic, political, and natural disasters that have occurred since 1945 with food, technical assistance, and credit.

American people have, and are right now, risking their lives and sometimes losing them in

Asia in order to prevent chaos and to alleviate human misery. We have many people working unsung and unknown to bring hope and relief to millions of people in Asia, Africa, and South America. Surely, we have sent out technical advisers of all kinds to teach people how to cope with their own unique problems of food, clothing, shelter, and health. We have operating now the Peace Corps, a bright but relatively small effort that has achieved promising results.

But as great and as noble as these efforts are, and as vitally important as they are in countering the subversion of the communist bloc, they are primarily corrective, not preventive, measures. We have sent out our foods, machines, and some talents. But have we really sent them the knowledge to attack the basic causes for their misery?

Suppose, for instance, we mounted a major effort to find a means by which malaria could be as effectively eliminated from Asia, South America, and Africa as we have eliminated smallpox or typhoid fever from America. Think of the human resources, the economic force, that would be released for effective and constructive work in those politically unstable areas.

Suppose that we mobilized our scientific resources to produce insecticides to wipe out permanently the locust plagues that annually threaten millions of people with famine. Would that not make them less susceptible to the blandishments of communism?

Suppose we effectively attacked the problem of illiteracy by the adaption through research of communication technologies in which we already lead the world. Would not the effectiveness of our program to broadcast the messages of freedom, the dignity of man, government by law not men, eventually be magnified many times over?

One might say that we are doing these things now. Yes we are—but in what fashion? Relatively, in dribs and drabs. We have not as yet on a national basis decided—not only for political reasons, not only for economic reasons, but for practical, pressing human reasons—to mobilize our research to attack these ills.

It is entirely consistent with the history of our country that the scientific community should be assigned such a critical and vital role. I firmly believe that the Biblical promise of the hundredfold return for bread cast upon the waters applies equally to nations as well as individuals.

It has long been acknowledged that our technological leadership of the Free World is based on an unmatched ability to translate into practical terms the results of research. There is no doubt that this is our special forte. It has been a unique force in the hands of our people. It has been the imprimatur of progress and dynamic energy. It has supplied a momentum to our society that has carried this nation through vicissitudes that have perverted or destroyed nations of our times and the past.

Our problem, then, is to maintain that momentum, to preserve the strength of that unique force, through those who will come after us. It is our task to make sure that our scientific research will continue to serve the needs of the world. This nation is faced with the never-ending problem of developing scientific and technical people of greater and greater competence to meet these challenges.

It is true that the current programs we have undertaken, best illustrated by our space program, are demanding such numbers of well-trained scientists and engineers that they threaten to strain our resources of competent people. Our urgent need for well-trained scientists, technicians, and engineers has already been reflected in educational institutions throughout the country, from the primary grades through the graduate degree level. Great progress has been made by educators to establish rigorous and demanding curriculums in our universities and secondary schools. We have clearly understood the threat of the Soviet Union to achieve parity, both economic and military, by increasing manyfold the numbers of scientists, engineers, and technicians available to the Soviet economy. It is a well-known fact that following World War II, the Soviet educational effort received such concentrated emphasis that, today, Russia is producing two to three times as many scientists and technicians as we are. And there is no question that the Soviet Union fully intends to accelerate further its educational programs.

But what kind of scientists or engineers are the Russian institutions producing? Do these people match our image, our conception of what professionally trained people should be—well developed professionally, intellectually, and culturally? I think you will agree that we see in the average Soviet product of today a very well-trained individual who has been neglected in the development of those human qualities that would permit him the intellectual freedom to seek out and recognize absolute truth. And it is truth, and the ability to relate that truth to human progress, that is the credo of science.

We, in buttressing our defenses against the onslaught of Soviet technology, must not go the same route as have the Russians. We must not through our competitive instincts and because of the urgencies of our day, limit or ignore the need for the philosophical development of our students.

President Barnaby C. Keeney of Brown University expressed his thoughts quite eloquently on this. He said:

> There is no question but that advancements in science and technology have a greater immediate utility in the international and national situation in which we exist today. On the other hand, the whole shape of our lives in the future, and our whole attitude toward life will be strongly formed by our achievements or lack thereof in the arts and humanities.

Former Commissioner of Education, Dr. Sterling M. McMurrin, concurs with President Keeney by saying:

> The need for superior attainment in the sciences to guarantee our national security in the face of grave international crises has long been recognized by most Americans. There is an equal need for superior attainment on a very broad scale in the arts and humanities if Americans generally are to gain a full understanding of their rich cultural heritage and a genuine commitment to their ideals of individual freedom and human dignity. Only with such understanding and such commitment on the part of all of its citizens will this nation have the resources in personal and public creativeness and courage to meet successfully the continuing international struggle between freedom and tyranny.

We must continue to produce people who have been well-grounded, who have been trained how to think, how to use their minds, and how to apply their talents.

Here we are free from government limitations of career choices, and our graduates from higher institutions find their own niche in our economy. Here individual talents, whether in the sciences, humanities, or the arts, have the equal opportunity to become fully developed and refined.

Their usefulness has been limited only to the extent to which our economy can utilize them. Thus, it is extremely heartening to me to realize that in our national community, characterized by dignified freedom of choice, we have achieved the highest levels of scientific and technological accomplishment in history. And it has been our educational institutions that have made a major contribution to that achievement.

I believe we must continue to foster and encourage in every way possible the breadth and depth we try to maintain in our approach to education. We need and must continue to produce greater numbers of people of higher scholastic achievement. And they must come from all the disciplines, not just from science and engineering.

Scientific research is neither good nor evil by itself. It is the use that men make of it that dictates the nature of its effect. And it is seldom the scientist who decides what use will be made of his handiwork. This is in the hands of others who will dictate whether scientific achievement is to be a blessing or a curse. It is the systems under which people work and live that will enable or pervert technology.

The use men make of science is not governed by science. It is governed by men's philosophical and moral judgments. It is repugnant for me to contemplate a society in which scientists are cultural paupers. I am repelled by the thought of responsible men not thoroughly aware of the power science gives them. The thought of a system in which science and technology has been glorified to the point where it becomes the end objective rather than the means to a greater and nobler end—the advancement of human progress—is anathema to me.

The basic integrity of our scientific community is an indispensable characteristic of this nation. It is here that the scientific leaders of our generation have been able to find the intellectual climate in which to do their best work. I cite Einstein, Fermi, Seaborg, Von Karman, Lawrence, and Teller, to name only a very few.

Thus, I say our research needs are centered by circumstance, by logic, and by historical precedent in the elimination of those human ills that infect more than half the world's population. In all practicality and in all conscience, we cannot ignore that task if we are not to violate the moral basis upon which this nation was founded. And we owe to our children, to the generations to come, the opportunity to assume responsibility, such as that we now shoulder, by which future challenges to the rights of man can be courageously and willingly accepted.

Scientific progress in the United States, whether in government or in industry, will be the direct reflection of the men and women who will lead or support it. It will be all of us, however, who will be responsible in great measure as to whether our memory will be blessed or damned.

Chairman: **Harry R. Lange**
Vice President, Cutter Laboratories
Member, Oakland City Council

TWENTY YEARS OF ECONOMIC AND INDUSTRIAL CHANGE

Dr. Robert A. Gordon

DR. ROBERT A. GORDON, Professor and Chairman, Department of Economics, University of California at Berkeley; Director, National Bureau of Economic Research; Social Science Research Council, Director 1955–60; Chairman, Committee on Economic Stability; Research Advisory Board, Committee for Economic Development; Consultant to President's Council of Economic Advisors; Chairman, President's Committee to Appraise Employment and Unemployment Statistics. Johns Hopkins University (AB); Harvard University (MA, Ph D).

WE ALL TAKE IT FOR GRANTED that we have been living through a scientific and technological revolution during the last 20 years, and references to the New Industrial Revolution are common. We point to such developments as nuclear energy, electronics, jet propulsion, breathtaking advances in applied chemistry, the new forms of electronic mechanization that we call automation, the startling accomplishments of the new computers and data-processing equipment which (among other results) are bringing automation to the office, and so on. We know that science and technology are affecting our everyday lives and the affairs of business as never before. The letters R and D have taken on a new significance, and expenditures on research and development—in industry, government, and private nonprofit institutions—have mounted astronomically. One might say that the good spaceship "R&D" is already far out on its way to the moon and to destinations even more distant.

The new role of technology in today's world has recently been described by Robert Heilbroner in the following well-chosen words (ref. 1):

> This extraordinary predominance of technology is the decisive characteristic of modern times. The political and ideological agonies of our age are not without parallels in the past. What gives them their "modern" character, what distorts their historic comparability, is above all the technological attributes of the situation to which they now apply. The conduct of peace as well as war, the most routine flow of the economic process, even the intimate details of social existence must cope, at every instant, with the magnifying presence of a gigantic and dynamic technological foundation for contemporary life.
>
> And what is perhaps more chastening is the realization that we are still only entering upon this age of technological predominance. Science—the moving force behind technology—is only now emerging from its infancy: it has been said that of all the scientists of whom civilization has any knowledge, 90 percent are alive today. And industrial technology—the practical handmaiden of science—is equally new: half of all the research and development expenditures in the history of the United States have been made in the last ten years. Hence, the curve of the technological revolution continues to rise nearly vertically beneath our feet. With each year its impact—on work and play, on mind and body—becomes more unmistakable, more inescapable.

This new technological world, with its promise and portents for the future, is indeed breathtaking. However, the purpose of this paper is not to peer into the future but to look back at the behavior and changing structure of the economy during the past 20 years. Let us look at some of the major trends that we can discern since the end of the 1930's.

A good place to begin is with the size and composition of the Gross National Product, the total flow of newly produced goods and services purchased by consumers, business, government, and the rest of the world. This is the magnitude to which even the man in the street now familiarly refers as the GNP.

As we already know, accelerating technological change has not yet led to noticeable acceleration in the growth of total output of the American economy. Indeed, what we have chiefly heard in this regard in the last few years have been complaints about slow growth. Table I provides some perspective on trends in growth of total output in the American economy during the past half century.

TABLE I.—*Average Annual Growth Rates in GNP, in 1954 Prices, for Selected Periods, 1909–62*

[Growth rates up to 1957 computed by Committee for Economic Development. Those for periods ending in 1962 computed from data in *Economic Report of the President*, January 1963.]

Period	Annual rate of growth, percent
1909–29	2. 8
1929–39	. 4
1939–47	5. 1
1947–57	3. 8
1957–62	2. 9
1929–62	2. 9
1939–62	4. 0
1947–62	3. 5

In the period since 1939, the average annual rate of growth was a gratifying 4 percent per year, considerably higher than during 1909–29 (2.8 percent). But part of this represented merely putting to work the millions who were still unemployed in 1939. It is more useful to take the period 1947–62, which had a growth rate of 3.5 percent, still significantly higher than during 1909–29 although not as high as the 4-percent rate which is sometimes put forward as a goal to which we should aspire.

When we break down the postwar period into two subperiods divided by the year 1957, we see why the supposed slow growth of the American economy has become a subject of popular debate. The growth rate during the last 5 years has been significantly less than during the first decade after the war, and this deceleration has been accompanied by considerable excess capacity in industry and by a distressingly high average level of unemployment.

It will help us to understand why this deceleration has occurred if we look at the changing composition of the GNP portrayed in table II. Something like two-thirds of the GNP normally goes into goods and services bought by consumers. The fraction fell moderately between 1939 and 1947 and again between 1947 and 1957, primarily because of the effect of increased personal income taxes. As table II suggests, consumers' spending has held up relatively well

TABLE II.—*Percentage Distribution of the Major Components of Gross National Product for Selected Years, 1929–62*

[Each figure represents the percentage that the indicated component was of total GNP in the year indicated. Net exports are not shown. Original figures, on which these percentages are based, are in 1954 prices and were taken from *Economic Report of the President*, January 1963]

Year	Personal consumption expenditures, percent				Gross private domestic investment, percent			Government purchases of goods and services, percent		
	Total	Durable goods	Nondurable goods	Services	Total	Total construction	Producers' durable equipment	Total	Federal	State and local
1929	70. 5	8. 2	35. 9	26. 4	19. 3	11. 5	6. 1	10. 2	1. 6	8. 6
1939	72. 5	7. 0	40. 5	24. 9	11. 4	6. 4	4. 5	15. 9	5. 8	10. 1
1947	69. 3	8. 3	37. 3	23. 7	14. 7	7. 0	7. 7	13. 2	6. 9	6. 3
1957	66. 4	9. 4	32. 5	24. 5	14. 2	7. 8	6. 0	18. 5	10. 6	7. 9
1962	67. 4	9. 6	31. 5	26. 4	13. 3	7. 7	5. 0	19. 1	10. 3	8. 8

since 1957. Its share of total GNP has actually increased moderately.

Table II suggests that there have been some significant shifts among the major classes of consumers' expenditures. Spending on consumers' durables has increased in relative importance, as a fraction of GNP and even more as a share of consumers' expenditures. The share of GNP taking the form of consumers' nondurables has declined significantly.

The share going to services traces out an interesting path. It may come as a surprise to many that, *as a share of total GNP*, services showed a net decline between 1929 and 1947 and even last year were no greater than in 1929. We must remember, however, that total consumers' spending is now a smaller share of GNP than in 1947 or 1929. There has been a marked rise since 1947 in the proportion of consumers' spending going into services, and this fraction is now moderately higher than it was in 1929.

Turning now to recent trends in private investment or capital formation, it is through investment—in new buildings and particularly new equipment—that technological advances come to be embodied in new products and new methods of production. The picture revealed by table II is not altogether an encouraging one. Private capital formation has, throughout the postwar period, been a much smaller fraction of GNP than it was in 1929.[1] The great increase in the relative importance of government since the 1930's has been, to a considerable extent, at the expense of private investment. This we accept as a price of national security. What is more alarming is that the fraction has continued to slip in recent years. The share of capital formation in GNP was lower in 1962 than in 1957, and the share in 1957 was lower than in 1947.

Table II brings out another disconcerting fact about recent trends in private investment. As a share of GNP, it is expenditures on producers' durable equipment that have been particularly sagging in recent years. We may indeed be in the midst of a New Industrial Revolution, but, if so, it does not yet reveal itself in a big upsurge of business expenditures on new equipment. This is, incidentally, one of the factors (but only one of several) responsible for the poor performance of the steel industry in recent years. (Compare *Survey of Current Business*, Jan. 1962, pp. 9–13.)

The trends in government expenditures revealed in table II are, in a general way, familiar to everyone. All levels of government today absorb almost a fifth of total GNP, compared with 10 percent in 1929, 16 percent in 1939, and 13 percent in 1947. The big relative rise has been in Federal expenditures. National security accounts for all of this. As a fraction of GNP, Federal expenditures on goods and services other than for national defense were lower in 1962 than in 1947. Note also that since 1957 there has been a net decline in the ratio of total Federal spending to GNP.

The concern of this conference with urban problems suggests a look at the trend in state and local expenditures. Although the share of such expenditures in GNP has risen significantly since 1947, the fraction is still very little above where it stood in 1929. One useful calculation to make is to compute state and local expenditures as a share of the GNP after Federal expenditures are deducted. This figure was 8.7 percent in 1929; it jumped to 10.7 percent in 1939; it had fallen to 6.8 percent by 1947; and it has been rising steadily since then until it is now 9.8 percent, significantly more than in 1929.

Growth rates can be observed from a different point of view. Table III, which presents the results of some important recent research conducted by the U.S. Department of Commerce, reveals how fast the different industrial sectors of the economy have grown during various periods since 1929. The most rapid rates of growth since 1947 have been in communications

[1] A troublesome problem arises here. We are dealing with figures which have been deflated for price changes. The recorded prices of capital goods have risen much more than those for consumers' goods, and there is a considerable body of opinion to the effect that the official figures exaggerate the relative rise in the prices of capital goods, particularly if we take into account improvements in quality. It may be, therefore, that the figures in table II, which have been deflated by the official price indexes, exaggerate the decline in the share of private capital investment in GNP. (See ref. 2.)

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TABLE III.—*Rates of Growth in GNP by Industrial Sectors, 1929–60*

[Taken from *Survey of Current Business*, October 1962, p. 9]

Industrial sector	Annual rates of growth, percent				
	1929–60	1929–47	1947–60	1947–57	1957–60
All industries, total GNP	2.9	2.5	3.5	3.8	2.5
Agriculture, forestry, and fisheries	1.1	.4	1.9	2.0	1.8
Mining	1.3	.9	1.9	2.8	−1.2
Contract construction	2.1	1.2	3.4	4.7	−.7
Manufacturing	3.3	3.4	3.2	3.6	2.1
Wholesale and retail trade	2.7	2.5	2.9	3.0	2.5
Transportation	3.1	4.2	1.6	1.8	1.1
Communications and public utilities	5.8	4.1	8.3	8.8	6.6
Finance, insurance, real estate, and services	2.6	1.5	4.1	4.0	4.3
Government and government enterprise	3.9	4.3	3.3	3.8	1.5

and public utilities and in the service group, followed by construction, government, and manufacturing. Retardation since 1957 has been almost universal; only the service group has escaped. In the most recent period, manufacturing has not been expanding as rapidly as GNP as a whole. Very recent figures including 1961 in the calculations only reinforce these generalizations.

These trends in output and spending have reflected themselves in employment and unemployment.

After World War II, the total labor force grew somewhat more rapidly than the population of working age. Labor force participation rates increased, reflecting particularly the increased entry of married women into the labor force. This trend can be observed in table IV, which indicates that the labor force participation rate rose from 57.4 percent in 1947 to 58.7 percent in 1957. (The peak rate of 59.3 percent actually came in 1956.) Since then, however, it has slowly fallen. The discouragingly high level of unemployment in the last half dozen years has led some women and youngsters to stay at home who might otherwise have looked for work and has accelerated the movement of older men out of the labor force. (Increased schooling and changes in social security and in private pension plans have also affected participation rates.) These recent trends led the U.S. Department of Labor last year to revise downward somewhat its projections of the labor force to 1975. (See ref. 3.)

TABLE IV.—*Labor Force, Employment, and Unemployment, 1929–62*

[From *Economic Report of the President*, January 1963, p. 194]

Year	Total labor force	Civilian labor force		Labor force participation rate	Rate of unemployment
		Employment	Unemployment		
	Millions of persons 14 years and over			Percent	
1929	49.4	47.6	1.6	n.a.	3.2
1939	55.6	45.8	9.5	n.a.	17.2
1947	61.8	57.8	2.4	57.4	3.9
1957	70.7	65.0	2.9	58.7	4.3
1962	74.8	68.0	4.0	57.5	5.6

As is generally known, unemployment has been at a disturbingly high level since the business recession of 1957–58. We tend to think of "full employment" as corresponding to an unemployment rate of 4 percent. On an annual basis, unemployment has not been as low as 4 percent since 1953; it was 4.3 percent in 1957. Since then the annual figure has not fallen below 5.5 percent; it was 5.6 percent in 1962.

Thus, for at least 5 years the American economy has been operating at a level considerably short of full employment. A vigorous debate still goes on as to the extent to which this unsatisfactory performance is due to a deficiency of aggregate demand and the extent to which it is due to "structural" difficulties—particularly the imbalance between the skills and training of those looking for jobs and the skills and training called for by the considerable number of vacancies that are available. Almost certainly, both sets of factors are at work. There has been, and is now, a significant deficiency of aggregate demand—a deficiency which, incidentally, the Kennedy Administration hopes to eliminate in substantial part by its proposed tax-reduction legislation. (See, in particular, the *Economic Report of the President*, January 1963.) However, it seems fairly clear also that the unemployment problem has an important "structural" dimension arising out of the fact that many of the unemployed do not have the skills and training, or are not in the right places, needed to satisfy employers who do have vacancies. These problems will be considered further after a consideration of the differential trends that have manifested themselves in production and productivity in different sectors of the economy.

With the help of table V, consider trends in labor productivity, first in the economy as a whole and then in different sectors. (By labor productivity we mean simply output per man-hour.) During the period following World War II (1947–61), labor productivity has risen at a relatively high, although not unprecedented, rate. For the private domestic economy, excluding government, the rate of increase has been in the neighborhood of 3 percent, which is significantly higher than the average increase over the last half century. (See refs. 4 to 7.)

As table V suggests, there seems to have been some slowing down in the overall rate of productivity increase since 1957. There has clearly been some slackening in the amazingly rapid increase in agricultural productivity, but the evidence for the nonagricultural sector is somewhat conflicting, one set of measures showing some very slight acceleration and another (not shown in table) showing some deceleration. The values in table V suggest very slight acceleration. The increase in man-hour output in manufacturing seems to have accelerated; that in nonmanufacturing may or may not have done so. But the shift in demand from the commodity-producing to the service sector has tended to retard the growth of productivity in the economy as a whole below what it would have been without such a shift.

When we speak of the New Industrial Revolution, it is naturally *industry* that we think of, and that means chiefly manufacturing, but also mining, probably also the public utilities, and perhaps some branches of transportation. It may come as something of a shock, therefore, to note from table V that by far the largest increases in productivity in the postwar period have come in *agriculture*, not in industry. We have truly been experiencing an agricultural revolution since the 1930's. Since 1947, agricultural output per man-hour has increased at a rate more than twice that in the nonagricultural sector and also more than twice that in manufacturing alone. (This differential has narrowed in the last 5 or 6 years.) The results of this enormous increase in agricultural productivity are well known: large agricultural surpluses and the "farm problem" on the one hand, and a sharp decline in agricultural employment and an exodus to the cities on the other.

In the nonagricultural sector, productivity has tended to rise more rapidly in manufacturing than in nonmanufacturing, although productivity in some nonmanufacturing sectors has also risen very rapidly. More generally, productivity has, on the average, risen somewhat more rapidly in the industries producing goods than in those producing services. On the other hand, output has been expanding more rapidly

TABLE V.—*Average Annual Percentage Change in Output Per Man-Hour and Employment, 1947–61*

[From *Manpower Report of the President* and *A Report on Manpower Requirements, Resources, Utilization, and Training*, March 1963, p. 68]

Sector	Average annual percentage change			
	Output per man-hour	Output	Employment	Man-hours
1947–61				
Total private economy	3. 0	3. 4	0. 9	0. 4
Agriculture	5. 9	1. 5	−3. 3	−4. 2
Nonagriculture	2. 4	3. 5	1. 4	1. 1
Manufacturing	2. 7	3. 3	. 6	. 6
Nonmanufacturing	2. 3	3. 7	1. 8	1. 4
1947–57				
Total private economy	3. 2	4. 0	1. 2	0. 7
Agriculture	6. 3	1. 8	−3. 4	−4. 2
Nonagriculture	2. 5	4. 1	1. 9	1. 6
Manufacturing	2. 8	4. 3	1. 4	1. 4
Nonmanufacturing	2. 3	4. 0	2. 1	1. 7
1957–61				
Total private economy	2. 9	2. 9	0. 3	0
Agriculture	5. 2	1. 8	−2. 9	−3. 2
Nonagriculture	2. 6	3. 0	. 6	. 4
Manufacturing	3. 4	2. 8	−. 6	−. 5
Nonmanufacturing	2. 3	3. 0	1. 1	. 7

in the service industries than in the goods-producing sector. This combination of contrasting relative trends in output and in productivity has had a marked effect on the distribution of available jobs. There has been a marked shift in employment away from manufacturing and mining and toward the service industries. And, as is well known, there has also been a striking shift from blue-collar to white-collar jobs.

Some of these trends in the distribution of employment can be discerned in tables VI and VII. Table VI shows the marked decline in the relative importance of manufacturing employment since 1947, the even more radical decline in mining, and the significant decrease in transportation and public utilities. (In absolute terms, employment in manufacturing increased by about 1.5 million, or 10 percent, between 1947 and 1957, but *decreased* by almost half a million, or 2.5 percent, during 1957–62.) The big relative gains in employment have been in the service industries and in government.

TABLE VI.—*Wage and Salary Workers in Nonagricultural Establishments, 1929–62*

[From *Economic Report of the President,* January 1963]

Industrial sector	Percentage of total wage and salary workers				
	1929	1939	1947	1957	1962
Total wage and salary workers	100.00	100.00	100.00	100.00	100.00
Total manufacturing	34.15	33.57	35.43	32.46	30.28
Mining	3.47	2.79	2.18	1.57	1.17
Contract construction	4.78	3.76	4.52	5.53	4.87
Transportation and public utilities	12.50	9.59	9.49	8.02	7.09
Wholesale and retail trade	19.54	20.99	20.40	20.58	20.91
Finance, insurance, and real estate	4.82	4.77	4.00	4.68	5.05
Service and miscellaneous	10.98	11.49	11.51	12.76	14.02
Government (Federal, State, and local)	9.78	13.05	12.47	14.41	16.60

TABLE VII.—*Percentage Distribution of the Working Population by Major Occupation Groups, 1940, 1950, and 1960*

[Source: U.S. Bureau of the Census]

Major occupation group	Percentage distribution		
	1960	1950	1940
Total	100.00	100.00	100.00
White collar workers	42.2	36.6	31.1
Professional, technical, and kindred workers	11.4	8.6	7.5
Managers, officials, and proprietors, excluding farm	8.5	8.7	7.3
Clerical and kindred workers	15.0	12.3	9.6
Sales workers	7.4	7.0	6.7
Manual and service workers	51.5	51.6	51.5
Manual workers	39.7	41.1	39.8
Craftsmen, foremen, and kindred workers	14.3	14.1	12.0
Operatives and kindred workers	19.9	20.4	18.4
Laborers, except farm and mine	5.5	6.6	9.4
Service workers	11.8	10.5	11.7
Private household workers	2.8	2.6	4.7
Service workers, except private household	9.0	7.9	7.1
Farm workers	6.3	11.8	17.4
Farmers and farm managers	3.9	7.4	10.4
Farm laborers and foremen	2.4	4.4	7.0

Table VII throws some more light on employment trends in the last 20 years. Here we can trace the rise and decline of particular occupations. The most striking change, as we should expect, is in the increased importance of white-collar workers—from 31 percent of the working population in 1940 to 42 percent in 1960. Within the white-collar group, the most striking increases have been in the professional-technical and in the clerical categories. As we have been led to expect, manual workers have declined in importance, particularly unskilled laborers. It is not surprising to note the growing importance of service workers—or the relative decline in private household workers since 1940. The most dramatic set of figures in table VII are those for farm workers, who have declined from 17 percent of the working population in 1940 to a little over 6 percent in 1960. The number of farmers in the United States has been reduced by *more than 60 percent* in the last generation.

One aspect of the impact of recent industrial trends on the pattern of employment opportunities is strikingly brought out in table VIII. During the first postwar decade, when total nonagricultural employment increased by over 9 million, manufacturing provided about as many new jobs as did the service industries. In the decade ending in 1957, all industrial sectors except mining contributed to the total increase in employment, although the contribution was very small in the transportation-public utilities group.

Contrast this with the situation since 1957. Government and the service industries alone accounted for more than the net increase in wage and salary workers in the economy as a whole. Or to put it another way, four sectors—manufacturing, mining, construction, and transportation and public utilities—experienced an absolute decline in employment that added up to nearly half the net increase that occurred in the country as a whole. Or to state the matter in yet a final way, of the total increase that occurred in the sectors with expanding employment, almost one-third was offset by the actual decline in employment that occurred in these four sectors with declining employment.

To understand the situation more fully requires an analysis of the differential incidence of unemployment. The relevant data for a recent month are shown in table IX. In January 1963, the unemployment rate, *not* seasonally adjusted, was 6.6 percent. (The Department of Labor does not publish current estimates of

TABLE VIII.—*Industrial Composition of Increases in Numbers of Wage and Salary Workers, 1947–62*

[From *Economic Report of the President*, January 1963, p. 201]

Industrial sector	Net increase in employment			
	1947–57		1957–62	
	Total, thousands	Percent	Total, thousands	Percent
Total increase in nonagricultural wage and salary workers	9, 023	100. 00	2, 421	100. 00
Manufacturing	1, 629	18. 05	−424	−17. 51
Mining	−127	−1. 41	−181	−7. 48
Contract construction	941	10. 43	−227	−9. 38
Transportation and public utilities	75	. 83	−316	−13. 05
Wholesale and retail trade	1, 931	21. 40	685	28. 29
Finance, insurance, and real estate	723	8. 01	316	13. 05
Services and miscellaneous	1, 699	18. 83	1, 008	41. 64
Government (Federal, State, and local)	2, 152	23. 85	1, 559	64. 39

all of these detailed breakdowns of the unemployment data on a seasonally adjusted basis.) Contrast the different impact of the overall situation on the different groups identified in table IX.

TABLE IX.—*Unemployment Rates By Age, Sex, Color, and Occupation, January 1963*

[From U.S. Department of Labor, *Monthly Report on the Labor Force*, February 1963]

	Unemployment rate, percent
Total	6.6
Age and sex:	
Male	6.6
14 to 24 years	12.6
25 years and over	5.5
Female	6.6
14 to 24 years	10.6
25 years and over	5.6
Color:	
White	5.9
Nonwhite	12.7
Occupation:	
Professional, technical, and kindred workers	1.9
Farmers and farm managers	1.1
Managers, officials, and proprietors, except farm	1.3
Clerical and kindred workers	4.0
Sales workers	5.7
Craftsmen, foremen, and kindred workers	8.0
Operatives and kindred workers	9.0
Private household workers	5.0
Service workers, except private household	6.8
Farm laborers and foremen	10.4
Laborers, except farm and mine	17.8

By age, it is the young who are particularly hard hit. The unemployment rate among those 14 to 24 was more than double that among their elders. More serious, the unemployment rate among the young has been increasing more rapidly than for the labor force as a whole.

Even more striking is the contrast between whites and nonwhites. The unemployment rate among whites was 5.9 percent. The rate among nonwhites was more than double this figure—12.7 percent. This tragic differential prevails among both men and women. (The differential also holds for different age groups. Nonwhite teenagers have one of the highest unemployment rates of any age-sex-color group—no less than 21 percent for boys and 28 percent for girls in 1962. See *Manpower Report of the President*, Mar. 1963, p. 43.) A major effort to reduce this differential is now underway, with both the Federal Government and a variety of private groups participating. But conflicting trends are at work. On the one hand, slow but slightly accelerating progress is being made in opening up job opportunities for Negroes and in improving their education and training. But, on the other hand, the occupational shifts—from blue-collar to white-collar jobs and with the increasing emphasis on education and technical training—militate against any rapid reduction in the differential unemployment rates for Negroes lacking the required education and training. This is apart from the unquestioned racial discrimination in hiring practices that exists in wide sectors of the economy. The bald fact of the matter is that the differential in unemployment rates for whites and Negroes has actually widened in recent years.

The last part of table IX provides one more way of looking at the differing incidence of unemployment. The data presented here provide additional evidence on recent and current trends in employment opportunities, as these trends have been shaped both by changing demands and by technological developments. Consider first the low unemployment rate among farmers. A farmer, no matter how low his income may be, is obviously employed. Unemployment among farmers operating their own farms is largely of the "disguised" variety.

Next, contrast the extremely low unemployment rate in the professional, technical, and managerial categories with the very high rates among unskilled laborers. The highest unemployment rate by far, a distressing 17.8 percent, existed in January 1963 among unskilled laborers. (Seasonal factors made this rate higher in January that it would be over the year as a whole.) The unemployment rate was lower than average among clerical, sales, and household workers. It was higher than average among craftsmen and foremen and operatives. Unemployment among service workers was close to the overall average.

Here we can see the New Industrial Revolution at work. Technological change has been eliminating unskilled and semiskilled and even skilled jobs in manufacturing, mining, transportation, and the utilities. Yet in most of these sectors, demand has not been expanding rapidly enough to offset the job displacements that have resulted from the particular forms that increased productivity has taken. And the men displaced from unskilled and semiskilled types of manual work usually do not have the training—and often not even the minimum basic education—needed for the white-collar and technical jobs that are being created. This is a problem to which the Nation is increasingly addressing itself but to which there are no quick or easy solutions.

One final comment may be made about the pattern of unemployment that has emerged from the interaction of too slow a rate of growth in aggregate demand and the particular forms which technological developments have been taking. There has been some tendency for the average period of unemployment to increase. The average duration of unemployment was 8.1 weeks in 1953, 10.4 weeks in 1957, 12.8 weeks in 1960, and 14.7 weeks in 1962. The number unemployed for half a year or more in 1961 was higher by a considerable margin than it had been in any previous year since World War II. Even with moderately improving business conditions, there were more long-term unemployed in 1962 than in any previous postwar year except the recession years of 1958 and 1961. Here is further evidence of a type of "structural maladjustment" that we are still struggling to solve. These figures on the duration of unemployment can be found in the statistical appendix in the most recent *Economic Report of the President.* A detailed breakdown of the most recent figures can be found in the latest *Monthly Report on the Labor Force*, published by the U.S. Department of Labor.

Consider briefly some of the recent trends in research and development evident from the data of tables X and XI. We need pause only briefly over the spectacular upward trend in total expenditures on R&D revealed in table X. These figures suggest that total spending on R&D approximately trebled in the decade following the end of the Korean War. As the absolute totals increase, we naturally should expect some retardation in the percentage rate of expansion. Nonetheless, a recent informed forecast projected R&D expenditures at the end of the 1960's at more than $22 billion. (See ref. 7.)

The breakdown of these figures provides considerable room for thought. The fraction of total R&D financed by the Federal Government has been steadily expanding. Table X suggests that in the last few years the Federal Government has been supplying something close to two-thirds of all the money being spent on R&D in the United States. If we are currently going through a new scientific and technological revolution, it is rather a socialistic one—at least in terms of the source of the money.

Although most of the money is coming from Washington, most of the actual work on R&D is taking place in private industry, and predominantly in very large firms. Of total R&D expenditures in 1960–61, approximately three-quarters occurred in industry, 15 percent in government, and 10 percent in the universities and other nonprofit institutions.

These figures help to prepare for the bottom lines of table X. Considerably less than 10 percent of R&D expenditures have been going into basic research. Or to put it the other way around, more than 90 percent of R&D spending has been for applied research and development—chiefly development. (Compare *Economic Report of the President*, Jan. 1962, p. 124.) Of the amounts being spent on basic research, the Federal Government finances a significantly smaller share than it does of applied R&D. A very small fraction of R&D spending in industry goes for basic research. It will come as no surprise to note that the universities (and other nonprofit research organizations) have been responsible for more than half of all the basic research being conducted in the country.

Consider now the data of table XI which lists separately each of the industrial sectors that spent $200 million or more on R&D in 1960. It comes as no surprise to discover that more than half of total R&D was spent in two industries—aircraft and electrical. (This, of course, reflects the concentration of defense contracts.) In the former, some 90 percent of the funds were provided by the Federal Government; in

TABLE X.—*Funds for Research and Development and for Basic Research, 1953–61*

[From *Statistical Abstract of the United States*, 1962, p. 542]

Period	Total, billions	Percent supplied by Federal Government	Performance, in billions, by		
			Federal Government	Industry	Universities and others
Research and development					
1953–54	$5. 15	53. 2	$0. 97	$3. 63	$0. 55
1954–55	5. 62	54. 6	. 95	4. 07	. 60
1955–56	6. 39	57. 4	1. 09	4. 64	. 66
1956–57	8. 61	59. 2	1. 28	6. 54	. 79
1957–58	10. 03	63. 6	1. 44	7. 66	. 93
1958–59	11. 07	64. 8	1. 73	8. 30	1. 04
1959–60	12. 62	65. 8	1. 83	9. 55	1. 24
1960–61	14. 04	65. 7	2. 06	10. 50	1. 48
Basic research					
1957–58	$0. 834	50. 6	$0. 111	$0. 271	$0. 452
1958–59	1. 016	55. 8	. 221	. 305	. 490
1959–60	1. 150	56. 2	. 220	. 345	. 585
1960–61	1. 302	57. 2	. 245	. 382	. 675

TABLE XI.—*Funds for Performance by Industry for Research and Development and Basic Research, 1960*

[From *Statistical Abstract of the United States*, 1962, p. 543. Values are preliminary]

Industry	Research and development		Basic research, total funds for performance, millions
	Total funds for performance, millions	Federal funds for industrial performance, millions	
Industrial chemicals	$737	$297	$81
Petroleum refining and extraction	289	25	52
Machinery	993	384	28
Electrical equipment and communication	2, 405	1, 634	74
Motor vehicles and other transportation equipment	849	216	9
Aircraft and parts	3, 482	3, 027	39
Scientific and mechanical measuring instruments	228	145	3
All other industries	1, 516	399	95
Total	$10, 499	$6, 127	$381

the latter, about two-thirds. In both cases only a tiny fraction went into basic research.

In sharp contrast stands the petroleum industry. Less than 10 percent of its R&D came from Federal funds, and it spent a larger fraction on basic research than any of the other industries listed. Chemicals, machinery, and transportation equipment fall into an intermediate position with respect to reliance on Federal funds. Next to petroleum, the heaviest relative emphasis on basic research is found in chemicals (as we should expect).

The major inferences to be drawn from all of these figures such as contained in tables X and XI have frequently been commented on in the literature. Government has been the chief source of support for research and development, and the largest part of R&D has been oriented toward defense and, more recently, the space program. Until now, the emphasis has been on applied research and, in industry, even more on relatively simple development expenditures. Reflecting all of these trends, R&D expenditures have been heavily concentrated in a very few industries. Perhaps most alarming is the relatively small amount that has been spent on basic research in the last 15 years. To some extent, the New Industrial Revolution has been living on its intellectual capital.

There is some reason to believe that developments in R&D in the decade ahead will be in desirable directions: some decline in the extent to which R&D is oriented to defense needs; somewhat greater reliance by industry on its own funds; accelerated expansion of R&D in sectors in which it has so far been of minor importance; greater emphasis on basic and applied research and somewhat less on mere product and process development; accelerated investment in basic research and, in this connection, relatively more generous support of academic research; and greater emphasis on disseminating the results of research resulting from government support. (See ref. 7, pp. 355–69.)

Table XII summarizes some of Edward Denison's most important findings regarding the sources of past and potential future economic growth in the United States. (See ref. 8, p. 266.) It should be mentioned that Denison has ventured onto virtually untrod ground, and his estimates are by no means universally accepted. But they are highly suggestive nonetheless.

According to table XII, of a total growth rate averaging 2.93 percent during 1929–57, 1.57 percentage points can be ascribed to increased quantity and improved quality of labor; only 0.43 percentage point is ascribable to growth of the capital stock; and 0.93 percentage point resulted from increased output per unit of input—almost entirely from the advancement of knowledge and the economies of scale resulting from expanding local and national

TABLE XII.—*Suggested Allocation of Growth Rate in Real National Income Among the Sources of Growth, 1909–57, and Projected, 1960–80*

[Derived from ref. 8]

Sources	Percentage points in growth rate		
	1909–29	1929–57	1960–80
Real national income	2.82	2.93	3.33
Labor	1.53	1.57	1.70
Employment and hours	1.11	0.80	0.98
Education	0.35	0.67	0.64
Other	0.07	0.10	0.08
Capital	0.73	0.43	0.49
Increase in output per unit of input	0.56	0.93	1.14
Advance of knowledge	(a)	0.58	0.75
Economics of scale	(a)	0.34	0.33
Other	(a)	0.01	0.06

[a] Not available.

markets. Compared with that during the 20 years before 1929, the contribution of education and (presumably) the advancement of knowledge increased; the contribution resulting from growth of employment and capital declined.

Denison intends these figures, and the intensive research that lies behind them, to point up an important moral. That is that it is difficult to accelerate the rate of growth. Thus, despite the advances he foresees in scientific and technical knowledge in the generation ahead, he thinks that this item will contribute only 0.75 of a percentage point to the future growth rate, compared with 0.58 in the period since 1929. As his figures suggest, he believes that our efforts at improved education will do little more than keep constant the contribution that this factor makes to growth. On the basis of what he considers to be moderately optimistic assumptions, he projects a growth rate only four-tenths of a percentage point higher than in the period 1929–57. This modest acceleration, he estimates, will come about equally from accelerated growth in the labor force and from the accelerated advance of knowledge, supplemented by a small contribution from the growth of capital—the other sources of accelerated growth largely offsetting each other.

I think the moral of this story can be put about as follows: We do live in a dynamic world, and in a world of apparently accelerating scientific and technological change. But in terms of some of the dimensions in which we are interested, radical change is not so evident. We may send men to the moon, but we must still face the old problems of maintaining aggregate demand, of stimulating investment incentives in private industry, of adjusting our heterogeneous labor supply to radical shifts in the pattern of employment, of insuring that public investment in education and a broad array of other forms of social wealth grow at an appropriate rate and in the most socially desirable forms.

Our economic system is marked by change—but also by continuity and inertia. We have experienced a scientific revolution. We seem to be in the midst of a technological revolution. But on the economic and social side, now, as for a long time in the past, the appropriate word seems to have been "evolution"—and not infrequently painful evolution, at that.

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REFERENCES

1. ANON.: Automation and Technological Change. The American Assembly (New York), 1962, pp. 7–8.
2. GORDON, ROBERT A.: Differential Changes in the Prices of Consumers' and Capital Goods. American Economic Rev., December 1961, pp. 937–957.
3. ANON.: Interim Revised Projections of U.S. Labor Force, 1965–75. U.S. Dept. of Labor, Special Labor Force Report 24.
4. KENDRICK, JOHN W.: Productivity Trends in the United States. Princeton, 1961.
5. FABRICANT, SOLOMON: Basic Facts on Productivity Change. Nat. Bur. of Economic Res., Occasional Paper 63 (New York), 1959.
6. ANON.: Trends in Output Per Manhour in the Private Economy, 1909–58. U.S. Bur. of Labor Statistics, Bulletin No. 1249, December 1959. (Supplemented by releases each year.)
7. KEEZER, D. M.: The Outlook for Expenditures on Research and Development During the Next Decade. American Economic Rev., Papers and Proceedings, May 1960, p. 361.
8. DENISON, E. F.: The Sources of Economic Growth in the United States. Committee for Economic Development (New York), Supp. Paper No. 13, 1962.

DISCUSSION

Sumner Myers: Dr. Gordon, how would you take into account the lag between the time the new process or product is discovered and the time it's adopted by industry and introduced into the economy?

Dr. Gordon: I haven't taken it into account, except by implication, in this paper. The lag varies widely by type of innovation and the sector into which it is introduced. The problems we had in the last decade can be considered to be the result of the weighted average of a set of distributed lags, resulting from a variety of types of technological and other changes occurring since World War II, during the war, or some even before the war.

Dr. Richard Brenneman: Would you care to comment on the projection you made about the increase in Gross National Product in our economy compared to Western Europe and perhaps the U.S.S.R.

Dr. Gordon: The Russian rate of growth is substantially higher than ours and has been for quite a long while. The rate of growth in virtually every industrialized Western European country is substantially higher than ours, with the possible exception of the United Kingdom. There's some evidence that rates of growth in Europe have been slowing down in the last couple of years. They have been slowing down in Russia.

This is a process of industrializing. It's a New Industrial Revolution, in a different sense than the New Industrial Revolution that's presumably going on in the United States. It's an industrial revolution which simultaneously borrows heavily from a half century or more of the past and incorporates that with current new changes. They have a lot of catching up to do, and this helps to a considerable extent to account for the fast rates of growth. In our case we are coping with the problems that new technology creates, and as a result of that we have a rate of growth that reflects potential productivity in new technological and organizational developments, discounted by our inability to handle the adjustment problems that have arisen.

Robert Ryan: I wonder if another interpretation can't be drawn from Denison's figures. It would appear that if increase in output per unit of input means improved technology, and if you add to that the educational contribution to this percentage point addition, it would seem that education and technological improvement combined are in and of themselves a real source of economic growth. I didn't get that as your interpretation of these figures.

Dr. Gordon: They are a real source of growth. The moral I reported that Denison was trying to draw is that it takes a great deal to get an increase of one-tenth percentage point acceleration in growth out of some combination of these factors. He asks what we would have to do to have education add one-tenth of a percentage point to the rate of growth. The answer seems to be: More than the American people are yet willing to do. We talk about growth being related functionally to one variable, supply of labor; another variable, supply of capital; and a third variable, output of productivity or output per unit of resources. What we mean by that third variable is a big question mark. It's a catchall for all our ignorance, because if productivity per unit of factors of production increases, this increase in productivity supposedly has some source—an increase in knowledge, organizational improvements, improved quality of the labor supply, either in an educational, or some other, sense.

Think of growth occurring in the way that I suggested—as a result of a growth in the working population, growth in the capital the working population has to work with, and then everything else that determines how productive the labor and the capital are. Then make a list of the things which you think contribute to getting more output per hour of work or per dollar of capital. We've hidden an awful lot of ignorance by saying that growth of output is a result of an addition to the growth of labor supply and capital supply, and this addition is due to an advance in knowledge or some other general term of that sort. Hundreds, or shall I say thousands, of different elements which we haven't fully enumerated yet have contributed to the fact that we can get more out of our resources today per unit of resources than we could 10, 20, or 40 years ago. And the combination of those elements that makes us get more out of our resources has been changing—and changing in ways we don't fully understand. Have your scientific and technological revolution, but have a different base of education, and a different productivity and growth result.

Congressman Jeffery Cohelan: In respect to these data you presented and in particular as they pertain to structural problems of unemployment in aggregate demand, what economic tools should we use to remedy the situation, with specific reference to tax reform?

Dr. Gordon: A graduate seminar in economic policy, made up of some of the brightest graduate students in economics at Berkeley, has been putting together a document, which now runs approximately 30 pages, answering this question. We hope it will be available very shortly.

Alton Dickieson: Where in these tables does the output from people that work for the Federal and State Governments show up?

Dr. Gordon: There are no separate productivity measures for government employees because we have no way of measuring it. In our national income or gross national product accounts, we use a convention in handling government expenditures on direct services, that is payment to a Federal, State, or local employee. We take the measure of their output to be simply their wages and salaries. You cannot increase the productivity of a government worker, the way the figures come out.

Dr. Samuel Silver: In connection with your basic research table, I am curious to know the difference between your definition of research and development and basic research and also the format under which the research is set up.

Dr. Gordon: These are official statistics from the Federal Government, taken from a government document. They are in the form in which they are generally made available. And if there is real doubt on that question—and I'm sure there is—then this is a subject for research within the government department that puts them together and among the industries that report the figures. I cannot answer your question.

Chairman: **Howard G. Vesper**
President, Standard Oil Company of California
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THE IMPACT OF SCIENTIFIC TECHNOLOGY UPON INDUSTRY AND SOCIETY

Dr. Jerome B. Wiesner

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THE CREATION OF THE Office of Science and Technology is an indication of what has been happening to science in the United States. This office was created in 1961 to provide a formal mechanism for evaluating the scientific programs of the various agencies, for studying policy, and for informing the Congress and the public about the Federal Government's activities. It was not needed a decade or two ago; if one traces the evolution of the Office, or actually looks at the history of the research activity of the Federal Government, the reason becomes apparent. At the end of World War II, the R&D activities of the country barely exceeded a hundred million dollars a year. In the past year they amounted to about $15 billion. Our annual expenditures now exceed the total expenditure for science and technology by the Federal Government from the beginning of this country through World War II. This gives some feeling for the magnitude of our scientific enterprise.

Prior to world War II there was a great deal of research, particularly basic research, in our universities, and a great deal of applied science and engineering, primarily in the industrial concerns of the country, though some of the defense laboratories of the Government also did development work. During World War II, we learned the great power of organized teams of scientists and engineers on special tasks to bring to bear the best of our abilities, the best intellects, and the total scope of available knowledge. We learned that in this way we could overwhelm almost any problem—or so we thought—by organizing and working hard enough. We continued after World War II with very extensive military development and research programs, and many people had major responsibilities for the creation and carrying out of those activities. We have had the large ballistic missile activity, the aircraft defense program, and a growing general research and development activity. We are more and more taxing the capabilities of the country in support of these activities.

As a matter of fact, during the period of the fifties we were living through a military-technical revolution but did not recognize it until it was forced upon our consciousness. The development of the thermonuclear bomb magnified the explosive power of the nuclear fission weapon by a factor of a thousand; the ballistic weapon had increased the speed with which things moved by at least one order of magnitude; and the computer had replaced the relatively slow-thinking man with an automatic machine that could literally work at the speed of lightning. The country was not adequately adjusting to these changes until the shock of the Soviet ballistic missile and Sputnik caused a very considerable reorganization, both in the Defense Department and in the executive office management of our technical affairs. At that time, the President asked Dr. James R. Killian to become his special assistant for science and technology. He had discovered suddenly that he had a very large enterprise with which he was not too familiar and which he felt needed specialized attention. At the same time, the Office of Defense Development, Research, and Engineering was set up in the Office of the Secretary of Defense. These two activities, along with the President's Science Advisory Committee and a number of other activities, helped during the next 2 or 3 years to steer the country through the missile-space revolution.

By 1961, this task was pretty well accomplished. We had successfully developed ballistic missiles and we had the beginning of the space program. A great many other problems had been brought about by the tremendous sweep of science and required attention; because of the stabilization in the earlier problems, these new problems have received much attention in the Office of Science and Technology. A great many people in the agencies helped, because in the activities in our office we have tried to work through and with the various agencies of the Government rather than create a very substantial independent organization. There are only fourteen professional people on my staff. It is my firm belief that we should try to maintain a very small staff, for the real problem in the Government is to get individual agencies to accept their own responsibilities and to work together. The primary role of our office should be that of conductor, to see that problems as they arise are resolved by group activity to the extent that this is possible.

I like to think of science and technology and its impact on our civilization as an extension of biological evolution. We came to be as we are through eon-long evolution by trial and error, and we have developed into extremely complex organisms which will perhaps never be thoroughly understood. But we are made of materials which have certain limitations. The speed of conduction of a signal, an electrical signal, on a nerve fiber is about 300 meters per second, a factor of a million slower than an electrical signal travels on a wire. The energy densities that we can generate in our muscles are quite limited. The speed with which we can move about is also restricted. Apparently in the process of evolution, we have become about as good a general purpose machine as can be made, using these rather poor materials that were available.

However, we have discovered, more or less inadvertently through the exploration of science, that there are ways of augmenting all of our human facilities. The reason modern civilization is able to provide a larger number of people with a more than adequate living instead of the situation which existed a few hundred years ago, where several hundred people would have to labor at subsistence levels in order that one person could live adequately, is that we have learned to use technological developments to extend our facilities. We now have thousands of horsepower available and at the command of one man. We have computers that can work in millionths of a second instead of fractions of a second. We have communications systems which can send messages around the world in fractions of a second. We can travel at speeds that sometimes seem too great. These things, then, are the tools that we have added to our biological inheritance to make it possible for us to cope more effectively with our environment.

We seem on the verge of being able to overpower our environment, providing we learn how to control man himself. We have learned another lesson, one that we could have learned from the biological evolution process, and that is: not everything new is good. The problem we face as a civilization is to avoid using the process that biological evolution used in selecting the specimens that led to modern-day man, for this was a fairly brutal process in which millions and millions of individuals perished. We have today the task of insuring that our civilization does not perish.

As we go forward, as we use the tools of science and technology to make a better world and to obtain the things we want, we have to learn to be much more thoughtful about the undesirable consequences, lest we wake up one day and find that we have unleashed some completely irreversible processes.

In the early period of the exploitation of scientific discoveries, we did not have this problem; or if we did, it was unrecognized. The major exploitations of scientific ideas and of inventions were done by individuals, and their ideas were accepted or not on the basis of a generalized vote by society. Society decided it wanted the automobile, and it bought the automobile. Society decided it liked the electric lamp, and it bought the electric lamp. Society did not like the Stanley Steamer, and it does not exist. However, we did not know at the time the automobile was developed that there would be a smog problem in California. We did not know when we did experiments in nuclear physics, that we would have to contend with the atom bomb. We did not know when we started using detergents that soon we would be unable to find any water without detergents. We are faced now with having to take a second look at the consequences of many of these things that we do.

There are a great many scientific problems which are particularly relevant to urban areas. One of the most important, surprisingly, is the problem of organization. That is, how do you run a town? How do you run anything? As the organizations we create grow larger and more complicated, we need more and more information for their proper management. We are learning that social sciences and the application of operational analysis, mathematics, computer techniques, and simulation can do a great deal to help us make judgments, to bring us the information that we need, to make models of experiments that we cannot conduct, and to give us guidance. There is a great need to accelerate and accentuate our studies in the behavioral and social sciences, not only for our urban affairs but for the entire management of our enterprises—private and public.

There are other serious problems. The pollution and contamination problems have already been mentioned. The problem of providing adequate water supplies is going to become an increasingly important one. The problems of noise reduction and elimination become ever more serious in growing metropolitan areas. The problems of privacy will also become important. Almost every metropolitan area of the country is arguing about transportation problems and searching for ways to alleviate congestion. Here also are fields in which much more effective use of simulation, of numerical analysis, and of economic studies can be made.

What can space research contribute to all of these developments? This is a hard question to answer. First of all, what do you mean by "space research"? Or, what do you mean by "research"? People lump together a tremendously diverse collection of things today—high-energy physics, any kind of experimentation, collecting data so a stock broker can write a news letter to his customers. But what I mean by basic research is the attempt to uncover new data—new information to provide understanding about the physical universe, inanimate and living. This is done by people who are primarily doing it because they like to do it. On the other hand, this is not why society supports research; otherwise, if it was done just for fun, we would see much more support of music and of art than exists. Society supports research because it has learned that on the average a dollar invested in research will yield very much greater returns.

The question is frequently asked, "How can the Congress judge how much research the country should support?" I really do not know the answer to that question although I have thought about it a good deal. I think the answer is this: Support should be given to all the basic research—research to add to basic scientific knowledge—that there are good people to do. Basic research tends to be relatively inexpensive. When we move on to the area of applied research, which means trying to find how we might use the basic knowledge in solving a problem, I believe that we should be considerably more careful because it is a good deal more costly. We ought to at least have some expectation that the problem applied research could solve is a problem we are interested in solving. Every day the Government receives many more proposals for work on interesting projects than we can possibly fund, or find people to do. I probably get more mail from people who have been turned down by NASA, by the Defense

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Department, or by the Atomic Energy Commission than from any other group. The Government could, if resources were available, fund five times the number of really substantial and good applied research or development contracts that it now does. The people in the agencies making the decisions have to exercise considerable selectivity.

Extreme caution should be exercised when the point of development is reached—that is, the point at which the applied research activities are projected to a stage of hardware where they can be used. It is here that the cost can go from a million dollar to a ten million dollar to a billion dollar kind of activity. It is absolutely necessary to be certain that what can be done is really needed. In the development of these very large programs, we have come to a point where we are taxing the citizens' patience; because the sums are large, we have a responsibility to be much more careful with the use of money than our predecessors did a decade ago when the funds were relatively small. We are also taxing our manpower resources, and we are taxing, in some instances, the industrial facilities. So the structure for coordinating, evaluating, and trying to integrate the Federal activities was required.

Another area for research in our modern civilization is in the field of education—trying to make learning more effective by trying to develop more effective curriculums, by trying to develop teaching machines of various kinds, by finding ways to use all the various modern teaching aids. Certainly among the most troublesome problems we have in all urban areas are those of adequately staffing our schools and adequately teaching our children to live in this modern world. The effort to generate science curriculums for the high schools and elementary schools of the country is one of the most important scientific activities now going on. It is my hope that these programs will be good enough so that every student will obtain an adequate understanding of the purpose, the methods, and some of the substance of science. These goals may be easier to attain today than they were 20 or 30 years ago because we know a great deal more about most areas of science today than we did 20 years ago. We have a much more coherent body of knowledge today, and for that reason it is easier to teach. Also, a great deal has been learned about how to teach. In particular, we have made a discovery—surprising only because it has taken so long to come—that by using task forces of specialists in education—in subject matter, in designing examinations, and in teaching aids—courses in the physical sciences or in the humanities or in the social sciences can be taught much more effectively than in the past when one teacher tried to do everything.

It is surprising that scientists and engineers, who have employed team effort on so many projects—for instance, radar—have taken so long to realize that team effort might pay off in education as well. NASA is attempting to assist in this whole educational process, particularly at the higher educational level, both by generating additional manpower (in part to pay back the society for the people it is employing), and by stimulating efforts of institutions to understand "spillover." Much of the research and development carried out in connection with the space program can be employed to advantage in nonspace and nonmilitary fields. However, application to other fields will not come without cost or effort. In other words "spillover" is only there—like an idea—if appreciated and used. A very determined, special effort is required on the part of individuals, the Federal Government, industry, and the communities to take advantage of many of these developments.

One of the properties peculiar to the problems of education, water research, noise elimination, studies of organization, economic dynamics, and health is that they are not activities that can be undertaken easily by individual initiative. They are not fields in which a man can start an industry and hope to obtain great personal rewards quickly. They are fields in which society has to decide to make an investment. In recent years we have become increasingly conscious of the need to do this at the state and the community as well as the national level. There is concern about the fact that we are using more and more scientists and engineers and other skilled workers in these enterprises. However, it seems to me that this is the direction the scientific evolution must take if we want to avoid the catastrophies that can come from not understanding these problems, from not exploiting the socially productive, scientific activities. If we want to obtain a "handle" on the unemployment problem, we must work more aggressively on these problems.

One of the encouraging trends in our society is that the quality of our labor force is improving with time. Our work force is a pyramid with the most skilled professionals—doctors, lawyers, engineers, scientists, teachers—at the top and the unskilled laborers at the bottom. The greatest shortage is at the top of the pyramid, and surpluses of manpower are at the bottom. The country is producing more—more people are living better—than a decade ago; and fewer people are involved in production. More and more of those formerly needed for semiskilled or unskilled labor in the past are available to be educated more nearly to their capabilities, to work more closely to their ultimate limits in such fields as teaching, basic research, social work, and management of our community activities. Thus, we not only have the opportunity to use science and technology to deal with these problems, but unless we use that opportunity, we will fail to solve the basic problems confronting us.

Chairman: **Dr. Kenneth S. Pitzer**
President, Rice University

SOME OPPORTUNITIES AND OBSTACLES IN TRANSFERRING NEW TECHNOLOGY AMONG VARIOUS SECTORS OF THE ECONOMY

Dr. Charles N. Kimball

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THIS DISCUSSION will probably concern the obstacles more than the opportunities involved in the transfer of technology among the various sectors of the economy; however, an effort is made to examine this issue in a realistic way. In many cases, the opportunities are simply the reverse of the obstacles.

There are three major sources for my observations: First is the insight we have gained over the past 18 years at Midwest Research Institute (MRI) in doing research and development on a contract basis in the physical sciences, engineering, and economics for a thousand different clients. Of these, 200 are government agencies and 800 are industrial firms, ranging in size from very small to very large.

The second input is the ASTRA project, in which we have been engaged since September 1962 for NASA in seven Middle West states. Briefly, we are engaged in a pilot program to take NASA's scientific and technical findings and to translate those into terms useful to industry and then to bring about a transfer of this knowledge. We have talked to about 3,000 people, representing some 700 different firms, to bring this potentially fruitful information to their attention.

It is not my purpose to go into much detail about the various findings we have ascertained and passed on, but it may be helpful to give an idea of the sort of thing that has been transferred. One is a lubrication of various types of machines with new types of bearings developed for space systems, both air bearings and solid-state lubricants. One manufacturer in particular has adapted the Marshall Space Flight Center air bearing to very heavy industrial equipment, and he foresees a considerable extension in bearing life. In another case, high-strength ceramics which were initially selected by NASA for missile fuel valves have been adapted and used for making precision resistors and have reduced breakage by 25 percent. New welding techniques evolved by NASA are cutting costs for many manufacturers. These techniques range from an eddy current crack finder to the simple expedient of using refractory tape for weld backup. In another case, metal working techniques, originally pioneered for coupling space vehicles, now permit both production of coaxial cables having a very low characteristic impedance, and in another instance, the corrugation of large, seamless tanks, making it possible to manufacture these tanks with much thinner metal.

The high-reliability soldering techniques devised by NASA in one particular case have made it possible to effect a 40-percent reduction in the incidence of failures in oil-well logging equipment. In two other cases, the use of Echo-type satellite skins for thermal insulation and for packaging special high-temperature protective coatings has a large area of interest.

A third input to this activity of ours has resulted from a survey of graduate schools of science in 15 universities in the Middle West, and 16 in the Southeast. This has been done under the direction of Dr. Thomas Smull of NASA. The work on applications has been accomplished under the direction of Louis Fong, NASA.

A fourth input comes from the fact that in the past year or so we have worked closely with some other groups who are concerned with the transfer of technology and also with the relationship of R&D to productivity and economic growth.

I feel that there is a long overdue need for attention to this matter of technology transfer. This need is illustrated in scores of ways: international prestige, balance of payments, growth of the economy, declining corporate profit margins, growing international trade competition, and so on.

Here are some of the facts of life, as I see them, which intensify the importance of these issues. By the year 2000 about half the people in the world will be Chinese and Russian, and the U.S. will then have about one-twentieth of the world's population.

Anyone who follows world developments is struck by the growing realization on the part of all countries that their future is strongly dependent upon the advancement and practical use of science and technology, whether their own or acquired from outside. An educated population will be the first requirement to the progress of any modern country. The ultimate weapons will not be military hardware but trained minds. To paraphrase a statement William James made at Stanford early in this century, "The world . . . has now begun to see that the wealth of a nation consists more than anything else in the number of superior men that it harbors."

Assuming that other nations progress industrially as have the U.S. and the Soviets, we may one day bear the same relationship to the world's economy that Switzerland does today to Europe—a small nation which has prospered by its inventiveness and use of technology. The postwar renaissance of Japan and western Europe, the fact that they are growing more rapidly than we are, has been viewed by many as an economic phenomenon, but it is not that simple. To say that their progress is due to postwar recovery begs the question. Their competition with our economy is far from being on the basis of price alone. It is also based on considerable technical excellence, evidenced, for example, by new Japanese steel furnaces, paper mills, electronic equipment, scientific instruments, and optics.

Furthermore, I am told that research and development, in certain other countries, is much more fruitful per unit cost than we obtain in the United States; that in England $2.25 of research is obtained for every dollar that would have to be expended in this country to produce the same quality and quantity of result.

The total research and development budget of the United States now exceeds the Gross National Product of most nations of the world. Yet the proliferation of research in the U.S. has not brought the industrial or economic growth that has been considered by many an automatic consequence of R&D. From 1954 through 1960, this country's R&D expenditures increased from $5.6 billion to $14 billion, from 1.55 percent of the GNP to 2.78 percent of GNP. However, for that same period 1954–1960, our average annual rate of economic growth was only 3 percent, down from 3.7 percent for the period 1947–1954. It is clear that we need a better understanding of the relationship between the two.

As Peter Drucker says, if we look at the last 10 years, we find that industry has been really good at spending research money, but still has a lot to learn about getting results. The United States has had 100 years of research experience to prove the economic value of research expenditures, and it ought to be the most profitable investment we can make. The fact that this is not always the case would indicate that we do not know how to manage research and its results in order to get economic results.

Nationally, we are facing a crisis in science and the appropriate use of the technology that results from it. In part, this may be a result of the sheer size of the effort following a period of very rapid growth. Big science had its genesis in the early '40's, but the problems associated with it were masked by the exigencies of wartime conditions.

The world has been involved in a 300-year scientific and industrial revolution, and yet there seems no limit to the exponential growth of science. One indication is the volume of scientific literature: More of it will be published in the next decade than has been produced since the beginning of time. Daily publication of scientific papers, worldwide, now fills seven sets of the Encyclopedia Britannica; yet 75 percent of the journals in our technical libraries lie virtually unused. Half of all the references and citations apply to only 10 percent of all the journals available. Does this mean that our progress is rapidly becoming asymptotic?

The utility of science/technology lies in what you can do with it to expand regional economies, corporate profits, government mission capability—local, state, or federal. We have generated billions of dollars of potentially useful information, yet somewhere along the line we are making grossly inadequate use of it. One reason may be the narrow base of R&D activity, the concentration in a very few industries and in a very few geographical areas. Three hundred firms in the United States do 80 percent of all the privately financed research. The same 300 firms do 99 percent of all the federally financed research available from the U.S. Government. Geographically, expenditures in R&D are eleven times greater on the West Coast than they are in the Middle West. NASA has shown unusual foresight in its emphasis on expanding the scientific base on which its programs must grow. The space effort is of such magnitude that new resources—in both universities and industry—must be developed.

Technology of transfer is not limited to relations between government and industry or between the public and private sector. There are potential transfer points within companies, within government agencies, between one public agency and another, between one group of scientists and another. There is a tremendous opportunity for all segments of the economy to benefit from the Nation's technological and scientific resources. That we are not benefiting fully is clear, I think. What are some of the reasons?

I see barriers to the transfer of technology in four major areas: (1) within corporate management, (2) within the scientific community, (3) in what I will call outside or institutional factors, and (4) within the human mind itself.

The first relates to management attitude or consideration, the lack of insight of management into the markets required for the results of research: new products, new processes. There is also an unwillingness of management to take risks. Managers in industry want to show a short term profit, and many are not willing to accept new technology, to do anything which might render existing plant and organization obsolete. As our work for NASA has pointed out, this is one reason why there is a much greater interest in new processes, new materials, new production techniques, which will require only incremental change, rather than in new products with the marketing risks and new plant investments which they so often imply.

Research is an investment, a highly uncertain one, requiring great management competence to produce results. Its cost is rising yearly. In fact, R&D costs are rising relative to other costs in the economy, yet there is still the widespread notion that if you just plow enough money in, results will come pouring out. Knowledge does not come out of industrial research unless the knowledge sought is focused on economic need. Then, too, people who use technology frequently fail to understand the range and utility of science, resulting in the unrealistic expectations of the role of R&D in business, the glamour aspects of science, its overstatement, and overexpectations. There is the failure on the part of most management to support the right kind of research projects. There has also been a tendency to overrely on institutional methods. The question is now being asked, "Is the central research laboratory passé?"

The trappings of research are often mistaken for its essentials. There are still many misconceptions, many fuzzy values—the elaborate research facilities, the large number of Ph. D.'s sought by industry. As someone said recently, "A region that complains of having too few defense contracts is no longer told just to elect more Democrats, it is told to spend more money on research."

Many businessmen either do not want to use government sources of information or do not know that they exist—for example, such sources as the Office of Technical Services, ASTIA, NASA, and the AEC. This could be due to several things—an antigovernment bias, or the tendency to regard the government only as a source of funds or a purchaser of R&D or hardware. There is little concept in business circles that government is a fruitful source of technological information. We need a whole new psychological framework here. Then there are other people who know there is much technical information available from government, but there is so much of it they hardly know where to begin. Perhaps the closest most business comes to benefiting from government R&D is the realistic group of companies who do R&D on contract, not so much for profit or for follow-on production contracts, but because their management knows they will learn something.

Closely related to the inadequate use of government R&D is the lack of rapport between industry and universities, thus shutting off a very logical source of new idea input, plus new information about technology. Hopefully, conferences of this sort will offset that lack of rapport in an appreciable way.

Another set of resistance points for technology transfer lies in the scientist himself. The Ph. D. who cannot write or communicate his findings or who has little, if any, economic understanding or drive is one example. There is the fact that many businessmen neither understand nor trust and, in fact, are afraid of intellectual types. There is the research director who shields his scientists from commercial pressures. There is the orientation of some scientists who regard research as a special privileged way of life and quite remote from the real world. This orientation is manifested in part by the rapidly growing preference, especially among younger scientists, to work on public problems, as opposed to those related to industrial problems and economic growth. There is the need also for research organizations to eliminate projects that are not promising economically and for research people to work more on problems on which they know their results will be used.

In the third set of obstacles there are barriers outside the company many of which are institutional in nature. An inadequate supply of real risk or venture capital, tending to invite government participation, is one such issue. In spite of their notable successes, financial firms like American Research and Development or Draper, Gaither, and Anderson are exceedingly rare.

It is hard for a company to keep up with technology on a wide basis, especially if the company is small. The mass of information is beyond the assimilation capacity of most firms. New product life is quite short, especially in consumer goods, a situation intensified by foreign competition. This increases the need for quick payout and ultimately the cost of corporate research.

There is a resistance to using new technology—old-fashioned building codes being one example. The resistance of labor to automation is another classic case. Or the useful transfer of technology can be impeded by suppliers on the one hand and customers on the other.

Another aspect of the lack of university-industry rapport is the unwillingness sometimes seen in university people—in both the hard and soft sciences—to relate their research or academic programs to the needs of industry. In many parts of the country, the geographic separation of industry and universities serves as an effective barrier to their getting together at all.

There are obstacles brought about by government activities. Seventy-five percent of all of the research people in the U.S. are funded by the Federal Government and are working on problems of a public nature. Many feel that this attracts the best people and that there is an inadequate supply and quality of researchers for private use. This is reputed also to be the cause of scientific salary inflation.

The government dissemination of new technology information is sometimes ineffective because the generating agency is mission-oriented, with little, if any, recognition on the part of people who generate information that transfer can or must occur. Both NASA and AEC have made great strides in providing means for facilitating transfer, but to most people generating the information, transfer will always be a secondary assignment, one they will normally concern themselves with only incidentally.

Security classification is a major problem in all military programs, where the bulk of the government R&D dollar is going, and the fact that defense and space research are concentrated in a very few industries means that widespread exposure to this source of technology is very small or indirect indeed, in a sense a form of unintended security.

The Nation's patent policies may well no longer provide the incentive for innovation that they once did, when the inventor and entrepreneur were usually incorporated in the same person.

The fourth obstacle to transfer has to do with creativity. There are either fewer creative people in the population today or the spectrum of required knowledge is so wide that many technically trained people do not want to take risks of the sort that technology transfer involves, tending to look more to security and certainty of a career than they formerly did. Creativity has usually been thought of as essentially an individual endeavor, but the structure of the American society has moved in such a way that most things—both economic and social—are accomplished in groups.

Yet despite this, there are companies that have been able to make money by doing research and transferring technology, but invariably they are either very large ones which have successfully overcome the compartmentation between the generators and users of technology, or they have been small firms managed by people who are both inventors and entrepreneurs. Examples would be the Varian brothers, William Hewlett, David Packard, Edwin Land of Polaroid, Dick Morse of National Research. This is the kind of man we need more of in universities, research institutes, and industry.

These four obstacles have been largely in the industry-Federal Government context. Many of my observations are equally applicable to state and local government and their relationship to industry and to other public bodies. For example, in the areas of air and water pollution, the application of computer systems to crime prevention and detection, civil engineering, and transportation, it is clear that transfer benefits have been few in spite of what appears to be a wealth of opportunity.

Now, what are some of the opportunities, what are some of the techniques available to make transfer more productive, a more vital process?

We have learned some things from our NASA experience that lead me to make some suggestions. First, before we can prescribe any long- or short-term improvement in transferring technology we must have a greater understanding of the relationship between the groups that produce it and those that use it. The effort must be organized to include three steps—to identify, to document, and to make available knowledge about innovations that have industrial significance.

Transfer of technology must be planned, yet the very words "fallout" and "spillover" imply accident. Transfer needs to be a purposefully pursued activity. It is really, in its essentials, a two-way technical intelligence service. Transfer must be related to expectations; only very rarely does transfer just happen. We can expect very few direct transfers like the jet engine. It is important to recall that even in this classic example, some 12 or 15 years elapsed between the appearance of the first jet aircraft in World War II and the first transatlantic jet flight. The mere fact that an innovation is made does not assure its rapid use; the diesel and many other examples also attest to this. It is only one of several factors, even though it is the key.

Most transfer will not occur in this "quantum" sense anyway. Like most things, the development is likely to be evolutionary, significant improvements in the state of the art, discoveries which will require a good deal of development to reach practical application.

There is nothing magic or automatic about the transfer of technology. The technology resulting from major R&D efforts of those outside a particular laboratory—whether the U.S. Government or private industry—simply represents another source of knowledge. The fact that many industrial firms take on government research when they do not expect to earn a profit strongly suggests that they are expecting some transfer benefits. A firm like Texas Instruments could be said to have benefited greatly from the transfer of technology from Bell Labs and its licensing arrangements. But the point is that it did not benefit until it made significant inputs of its own as well.

Our experiences at MRI, however, strongly suggest that the necessary transfer impedance match is more likely to be made by the transferrer than by the recipient unless the latter has highly developed entrepreneurial skills. The likelihood of that match is greatly increased when the transfer involves a new technique, a new material, or a new process which does not radically affect the recipient's existing business. The effectiveness of transfer is virtually unrelated to size of firm as such. The conceptual problem is a major one—only a small number of firms are accustomed to looking to nonrelated outside sources of information, beyond their suppliers, their competitors, or their customers. Industry, small or large, is prepared neither to receive nor to act on "fallout." The generating agencies are not oriented to produce it.

One essential step can be taken toward stimulating technical transfers: Identify and document the innovations as they occur. NASA is recognizing this opportunity in its own industrial applications program. We ought not to go on reinventing to satisfy our needs when the advanced technical means are even now available in another sector of the economy.

There are both short- and long-term opportunities in bringing about more effective technology transfer in this country. The short-term aspect has to deal with present people, present institutions, and present customs. The long term involves new people, new ways of doing things. These we will have to wait for but can prepare for now.

There is hope expressed in some quarters that the university can fulfill this transfer role, because of its wide interdisciplinary competence. It is the major institution which can hopefully understand the significance of basic science and its potential for technology. However, universities may need to add an entire new dimension of attitude to their activities.

Perhaps even new institutions are required to cope with big science and its relationship to economic growth. After all, most universities are still structured just as they were 100 or 200 years ago, but now need to cope with problems of very different scope and magnitude. In the beginning this probably cannot be done on an institutional basis. It may require man-to-man arrangements—development of mutual competence and respect. Results can be fruitful, but both business and universities can have a major role in developing working relationships.

It is a new relationship for many universities—a new point of view—looking outward to the region it serves as well as to customary educational responsibilities. It has been noted that the university needs to serve as the middleman in the transfer process. NASA has recently awarded a grant to the University of Indiana under which that university will find effective ways of identifying and disseminating information from the space program which has applications in private industry.

In another sense, the transfer role may be played also by the individual who combines both the inventor and the entrepreneur in one mind. This approach has been used by NASA in a corporate sense in assigning seven research institutes the task of evaluating over 400 potentially useful applications from the space program. With their wide range of technical competence and knowledge of industry problems, these institutes have long operated at a critical transfer point between scientific information and its industrial application.

Those who generate and use technology are currently overwhelmed by numbers and quantity, and yet what really counts in the information retrieval approach using computer systems is the relevance of the information going into and out of the computer. We must realize that there is a very rapid asymptote, a sense of diminishing returns—that our transfer concepts do not always require complete knowledge about a subject.

There is talk about an extension program for industry, analogous to the agricultural extension service. It may have to be very carefully structured to be successful. The agricultural equivalent worked beautifully years ago—and still does—because a farmer could tell within a year or so whether the advice he received bore fruit or grain. In a highly competitive industrial situation, such significant results will be more difficult to demonstrate clearly in such short periods.

There may be a need for the technical man 10 to 15 years out of school who has some proven entrepreneurial ability to be reeducated in his field to emphasize this aspect. The emphasis is now on producing Ph. D.'s most of whom have and are taught no entrepreneurial skills. The medical profession has taken advantage of entrepreneurial training and some businessmen too, with refresher courses at graduate business schools. Most scientists do nothing to broaden their spectrum but go to scientific meetings and thus compound the problem. It is significant that the Varians, Edwin Land, Richard Morse, and others had university access continuously to go with their entrepreneurial ability. The source of much new technology was close at hand and natural channels of communication available.

The objective of most undergraduate work is improvement of the individual. We need another form of impedance match to join the real world with the academic system. Other professions—law, medicine—recognize the importance of this match. There is no school granting an M.D. degree that is not affiliated with a hospital. However, academic people in the sciences and technology have not yet attempted this impedance match. In school, students solve problems in what might be called make-believe circumstances. We need internships, particularly in engineering where invention and technical innovation are required to such an extent. I am informed that Yale is experimenting with a method to provide clinical experience to engineers before granting the doctor's degree.

There may be a new use for the sabbatical year by people who generate knowledge as a career. They should also have to transfer knowledge as well. They ought to work at the transfer points of knowledge on occasion and not solely at the generating points. There is a transportation analogy to the choke point. What are the critical transfer points? I tend to think that they are in the area of the application of knowledge. Perhaps some scientists should take a year off from new approaches, new research, new theories—no new inputs.

There is more scientific and technical information available now, almost for the asking, than will ever be used. The rate at which it is compounding is still doubling every decade. If we do not learn how to bring about transfer now, it will soon be too late.

The great challenge is how to manage the transfer of useful information generated by scientists and engineers and to relate this to both public and private economic growth. This will be accomplished only by a mutually purposeful, continuous effort among research scientists, business leaders, the management of universities, and government officials at all levels.

DISCUSSION

Question: Dr. Kimball, you mentioned Edwin Land, the Varian brothers, and Dick Morse. All of these men successfully protected themselves by a very strong patent position and a Chinese wall of lack of transfer. Would you comment on this?

Dr. Kimball: They had to do the transfer before they got the patent. That might have been a consequence of the transfer, rather than the cause of it. I think that's my view.

Question: I'd like to raise the question: Didn't they ever break out of that Chinese wall or expand it into larger territory?

Dr. Kimball: A number of satellite people and companies came out of that relationship.

James E. Webb: We have in the NASA program simply taken advantage of the fact that we are required to expand resources for doing research, and we set the policy of trying to do as much as possible in universities. Therefore, where we are expanding and providing facilities and money, we are asking the university to do two things: First, to try to apply all of its disciplines and skills which it considers applicable to the problems at hand, rather than simply put them off with one group who are the most logical people to work on this problem, whether physicists or mathematicians. We want them to look consciously at whether there are other resources in the university that could make a contribution to the work we are financing on contract. The second thing we ask the university is to try to study the question of what additional uses can be made of the information which we are having them provide for our own uses. This means that they will be organizing teams to look at their own production and what they know of what others are producing, with the idea of deliberately trying to plan some transfer—or at least to try to understand whether it is applicable.

What will come from this, no one can say, but there are eight universities that have agreed to do this. It seems to me that one out of eight may find a new meaning.

Dr. Samuel Silver: I do not intend to argue with Dr. Kimball's point of view, because most of these are problems that have arisen at the University of California and have engaged our attention. This applies particularly to those of us who are in the College of Engineering and who feel very strongly that in an engineering college you have some relevance to the outside and to this so-called transfer problem and development of the economy. However, the thing that does concern me about Dr. Kimball's remarks about the university is the extrapolation that many may make from these remarks. I find the university is very much like a congregation and a rabbi or minister. Every member seems to know exactly what the minister ought to do, except that he wants to be sure that it doesn't involve him in any way.

The thing I am very much concerned about here is that in an attempt to utilize the university for this development—and certainly there must develop an understanding and relationship between the university and the outside—one loses sight of the purposes of the university, and the many facets of its activities. As an illustration—we have suddenly become very conscious of the student, in the sense that the student has to be literally nursed and fed. We have to take care of almost all of his intellectual hygienic processes. This has become such a serious problem that we have a developing activity in the country to try to deal with so-called engineering education. We are developing in the engineering colleges now what I feel is as much a disease and danger as the person who forgets the student entirely. We are developing professional educators, and this is now becoming an overriding problem.

We have to face up to this problem in its total relationship to the university and the community. What do you really expect out of the people in the university? If you expect them to become nursemaids for the students, then they cannot devote themselves at the same time to any kind of effective relationship with the community that involves things of the order of magnitude that we're talking about here today.

The same thing applies to research—the question of what are the purposes of research. Dr. Kimball combined into a hyphenated type of statement the scientist and engineer, and laid at the door of both of these a certain responsibility to transfer knowledge to the outside.

I think that one also has to realize that there's a reason for living which has to transcend some of these other problems. Why should people conduct research? And if we try to develop an overriding point of view to everybody in the university, or, in effect, anywhere, even in industry, and if the overriding demand has to be that the individual serve the community or serve the industry or serve the government—we will destroy the basic motivation of creativity. In fact, we destroy the individual.

This is one of the things that concerns me in the patterns that are developing in the United States today. Dr. Kimball brought up the question of creativity and put to us two possibilities. One is that there are fewer creative people around, and the second one is that they perhaps destroy their creativity in trying to secure for themselves a career. I don't believe that there are fewer creative people around. Given any generation, there is a certain potentiality for genius to emerge. However, a genius emerges in a given generation—in terms of thought—if his own cultural situation is such as to promote it. A genius can die on the vine if he is in a cultural situation which does not allow his particular element of genius to flower.

Consider the humanities—I think that the worst thing that could happen to the humanities today, in fact, the worst thing that could happen to the United States from my point of view, would be a government agency set up with the purposeful objective of supplying government funds to support the humanities.

Now, don't misunderstand. In no way do I feel that the humanities have to exist on starvation, that the greatest literature comes from the garret, or that the greatest creativity is based on an empy stomach. However, we have to analyze—and I think this is something that should follow this conference, because it relates to other aspects of the urban problem—we have to analyze our method of supporting research out of government funds, whether these are from Federal government, State government, or city government. The methodology of support of research in this country—which is very much conditioned by our Congressional system, by our whole legal and political system—is one which immediately exercises a certain direction to the research.

This isn't in any way the fault of the people who give out the funds. It isn't that anybody comes to me and says, "You have to work on this problem or that problem." But the point is we have a concept of government, a concept of budgets. Our budgets are set up on a 1-year basis out of Congress, and Congress must maintain control of this budget from year to year. This in turn is mixed up with the fact each congressman has an election on his hands every year—either he is getting elected or his ward heeler is getting elected or the president is getting elected. Each year he's concerned with a political problem. This begins to interact with the exercise and control of money. We have no mechanism here for setting up a system where money is transferred to a unit and then this unit can operate free from the political implications that go with it.

The point I want to make is that one of the things we must study very carefully for the future is how the university must be dealt with in relationship to these problems.

Question: I wanted to ask Dr. Kimball if he could comment on what I believe is an outstanding example of transfer, and that is the transfer of semiconductor work which was done at Bell Laboratories—the transfer was made in so rapid a time to the rest of the economy.

Dr. Kimball: I think one reason was that it was so very purposeful. I'd be the least well informed person to describe that because there are two or three Bell System executives here, and you might get their ideas.

Dr. Robert Solo: Bell Labs., uniquely in this case, made a concerted effort. It did have to release all its patents from the antitrust pressure. But it did more. It organized a seminar, extending about 2 weeks, and invited all people that it thought interested, who paid $25,000 advance royalty. For this seminar it prepared two texts, which came to be known as "Mother Bell's Cookbook." Bell spent at least 2 weeks working with people who had paid money to learn, and it took them into their laboratories. It was a living example of just what Dr. Kimball is saying—that transference requires an effort, a system. It doesn't just happen. It requires somebody fighting to do it.

Dr. J. Herbert Holloman: In this particular transfer, the most significant point is that Bill Shockley knew precisely what he was trying to do. What was it he knew? The people at Bell knew the general objective of substituting a solid-state device for a vacuum-tube component. They knew clearly in advance that, if successful, there was a market. They had made initial arrangements for the means by which the device would be manufactured to reach the market, that is, working with Western Electric, connected closely with Bell Telephone Laboratories.

It's true and also untrue that the patent licensing system forced Bell, because Bell already had cross-licensing applications for the Bell development in other than the communications field. Westinghouse, RCA, and General Electric, for example, all had cross-licensing agreements with respect to the transistor.

I think an important aspect of this is that Bell—recognizing the way technical developments do in fact take place and that the acceptability of the transistor, even in the Bell System, would depend on its acceptability by society as a whole—encouraged these other companies to be entrepreneurs, to exploit the Bell process. I think that this does, in fact, emphasize that scientific and technical entrepreneurship, represented by the fellow who knows something about the resources and science on the one hand and the application and requirements of the customer on the other, is a critical element in the process.

Dr. Solo: I think there's a difference here between successful research—that is, research that is organized from basic science into a practical application—and the transference of this from a company to a larger industrial sphere. What I was talking about was the transference of a created know-how into the semiconductor industry at large.

Benjamin Linsky: One of the classic examples of the problem that Dr. Kimball has been describing is in the field of storage and retrieval of nonquantitative information, the method of cross coordinate index system which ASTIA now uses. It was first developed in the early forties, I think, by the Air Corps, and is only now beginning to reach the humanities; it is still not known and not used by most of the industrial organizations with research groups; and it is resisted by the Special Librarians Association. Even the Communications and Symbols Systems group, the International Society of General Semantics, is just beginning to establish a library based on that principle. The dissemination of this marvelous tool has been a classic example of lack of foresight, lack of implementation, and lack of organization.

Chairman: **William F. Knowland**
Editor and Publisher,
Oakland Tribune;
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ECONOMIC, POLITICAL, AND SOCIOLOGICAL IMPLICATIONS OF EXPANDING SPACE AND SCIENTIFIC KNOWLEDGE

Dr. J. Herbert Hollomon

Dr. J. Herbert Hollomon, Assistant Secretary of Commerce for Science and Technology, Department of Commerce. Formerly: Manager, Metallurgy and Ceramics Department, General Electric Research Laboratory; General Manager, General Electric Research Laboratory; Faculty member, Harvard University and Rensselaer Polytechnic Institute. Recipient, Alfred Noble Prize, 1947, R. W. Raymond Award of American Institute of Mining Engineers, Rosenhain Medal of British Institute of Metals, Legion of Merit; Fellow, American Academy of Arts and Sciences and American Physical Society. Massachusetts Institute of Technology (BS, PhD).

We live in a world in which the national security and the weapons upon which it depends, the national prestige involved in the race to explore space, the social environment in which men have the opportunity to work and express themselves, personal health, and the health of the national economy all depend upon technical resources and their effective use by our people, by our industry, and by the agencies of our government.

The influence of the United States and the power of the national government depend fundamentally on our wealth and the well being of the national economy. Were we poor we would not be able to afford the weapons that determine our security, nor launch the vehicles to explore space, nor spend the enormous sums required to secure the health and welfare of our people and our free institutions. A necessary condition for the steady growth of the power and influence of the United States and for the western world to insure the spread of freedom is the well being of our national economy. The growth of the economy and the increasing output of goods and services on which all the rest of our security depends depend critically on the general availability and the general and effective use of technical resources. No longer are we so dependent upon natural resources or upon a limited supply of labor; rather, we depend upon our ability to develop, to use, and to invest in technical resources. The wealth of America, our ability to grow, our economy, our ability to provide a more satisfactory urban life, our ability to compete in foreign markets, all depend upon the effective use which we make of these crucial technical resources.

The activities that insure our national security and those that determine the prestige which may come to us from space exploration use the same kinds of technical people and the same basic science necessary for the growth of the economy. The activities that aim to fulfill these national purposes compete for the same resources, and the outcome of this competition determines the health of our society.

This brief discussion concerns the relationship between technical resources and the growth of our economy. Improvements in the economy depend fundamentally upon improvements in productivity. Without improvements in the output of labor and of capital, the national income would not rise, and we could not increase the purchase of goods and services to enrich our lives.

Many do not realize that the spread and use of new products and services are limited by improvements of productivity and the resultant higher income and not by the lack of new concepts or inventions. The spread in the use of the automobile and the resultant great influence on America waited for the advent of enough people to be wealthy enough to afford automobiles instead of horses. Compare the use of automobiles in the United States with that in the Netherlands. A decade or so ago, the Netherlands was a bicycle society, not because the Netherlanders—having many sophisticated technical people—could not invent, manufacture, and distribute automobiles, but because the people in the Netherlands simply did not yet have the income to dispose for the purchase of automobile transportation.

More often than not, an invention awaits the development of a market, awaits the emergence of people with money to buy the results of the invention. Many decry that there is a long lag between the invention and the utilization of a given invention by society. This lag will always be present. It would be sheer coincidence that the technical ability to achieve a given result occurred simultaneously with the need for that result by the society. Thus, the introduction of new technology for the economy is different from that for military and space purposes, both of which are limited by our physical capabilities. The jet engine was not used by the aviation industry of the United States or of any country in the world in the 1920's and 1930's, not because of the backwardness of industry, but simply because the jet engine did not provide sufficient benefit to justify the cost of its introduction into the aviation industry of the United States.

The increased ability of society to provide the means to purchase appliances, to purchase recreation, to purchase education, to purchase medical care depends upon a growing improvement in the income level and the productivity of our society.

During the last 50 or 60 years, agriculture has shown the greatest improvement in productivity. Even in recent years—in the last 10 years, as Professor Gordon so forcefully pointed out—the improvements in agricultural output have been far greater than the improvements in the productivity of American manufacturing workers, and the improvement in the services sector of our economy has hardly kept pace with the growth of the population. In 1950, one farmer produced food for 13 persons; in 1961, one farmer produced food for 27 others. This improvement in productivity was basic to the transformation from a rural to an urban society.

It is illuminating to compare the improvement of the U.S. economy with that of other nations, recognizing that enjoying as we do the highest standard of living of any nation in the world, we must be careful in comparing our rates of growth with those of other countries. During the last decade, the improvement in output (as measured by GNP) per worker or output per capital input of the United States has been less than that of any other major industrialized nation of the world, with the exception of Canada and the United Kingdom. The increase in the standard of living ("standard of living" as used herein means its generally accepted numerical measure, the improvement in the gross national product per unit of population) of the United States has been less than any other nation of the world with the exception of Canada.

As productivity is improved and new products and services are developed, the technical resources used to supply the demand become more and more sophisticated. Reeducation of the workers displaced from lower skilled jobs is required to make them available and able to work at the higher skills. Not only have we lagged in the introduction of new technology in the last decade but even with the slowed rate, we underinvested in the education and retraining necessary to balance employment and to take advantage of the improvements in the productivity of our plants.

Imagine that somehow or other today we educated 2 million unemployed people to be nurses, doctors, computer programers, college physics teachers, high school physics teachers, lawyers, scientists, and engineers. Could most of them be employed, even today? Clearly this part of the unemployment problem is a result of the lack of investment in the education that the constant improvements in productivity require and which are necessary if we are to enjoy the fruits of new technology.

With the improved productivity and with an adequately retrained and educated work force to do the higher skilled jobs, it is possible to provide, continually, new products and services to enrich our lives—adequate houses, television with color, travel, books, or whatever cultural and recreational things we wish to enjoy.

The growth in the economy—and the improvement in the output of our society—requires both the knowledge of what the customer is willing to buy and of the needs of society and the knowledge of the resources that are available in order to meet the requirements of the customer at a price. Today the limitations to providing the goods and services for our society through the economy are not so much the pace of the basic research but, rather, the willingness and the ability of the consumer to pay for the product, the people who are able to translate that demand into useful products, and the business managers who understand this process. It is not very useful to provide the new knowledge and techniques without the incentive and will to put them to use, or if the customer is unable or unwilling to expand his purchases. Today there is insufficient demand by the consumer and by the businessman for the products and services that the economy can provide. We can build plants that can produce more goods and services than we can now consume, or are willing to purchase. There is an enormous amount of technical information now available which we cannot put to use because we do not have the people, the tools, the techniques, or the opportunity to do so.

We must take steps to increase consumer demand. One way to do so is to reduce income taxes, both corporate and individual, to stimulate demand and the economy. Secondly, we must increase our ability *to use* technical information; to be able to put the results of research to work; to be able to utilize more effectively the advances that come not only from our space and military efforts but from the results of the efforts of the Europeans, the Japanese, and the Soviets, all of whom are advancing their economies at a rate equal to or superior to our own. To do so requires that there be people who are knowledgeable of the needs of the market; that there be an environment in which entrepreneurs—risk takers—can obtain adequate rewards; that technical resources are available throughout the whole of the country and not concentrated in certain areas, certain industries, or certain firms. Further, we must recognize that the market which United States industry serves is not wholly domestic. We now must compete for foreign markets and improve our competitive position abroad if we are to continue to grow economically and to solve one of the most difficult and complicated national questions—the imbalance of foreign payments. But we must also insure a broad market at home as well as abroad. If we have restrictive codes, restrictive standards, then we are not able to sell our goods in as many regions of the world or of the country as would be possible without them. In the building and construction industry, for example, inadequate, archaic codes prohibit the acceptance of new technology and the benefits of lower costs and of living comforts that would come from it. We should examine the costs and possible benefits of the adoption of the metric system. Adoption may help us to be better able to invade the markets of the world, so that American goods can be compatible with the standards which most of the world uses.

What are now the needs of customers? What are they willing to pay for? What does society want? I think the single most important factor affecting the changing needs is that there now are more people in the service industries in the United States than in manufacturing and agriculture combined; that we are buying new services and relatively less food and fewer goods. The services are largely those associated with an urban life—education, medical treatment, recreation—the new things that a growing urban society requires.

With so many evident new needs and with such a vast reservoir of scientific and technical knowledge, the important problem is the one referred to as "transfer," or "transition," or "how to utilize knowledge." The use of this scientific knowledge to provide the conceptions and the designs of goods and services to meet the needs of a society is simply "engineering."

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Engineering, which takes the technical and physical resources and combines them into designs to meet the requirements of the marketplace, is a subject which is no longer taught in most of our institutions in America. Our engineering schools have largely become schools of science, and people interested in the art of utilizing information for the purposes of our time and in the immediately practical needs of the community or of the country are often looked down upon by those who are interested in the sciences and by those in most of our universities and colleges.

There are graduate schools for engineering research, but hardly any graduate schools where a person can learn even the basis for the practice of the art of engineering, an art that now uses computer technology and sophisticated systems analysis.

If there is adequate incentive and if the needs of our time are known, and there are people who can design the means of meeting the need, then we must insure an adequate supply of the technical resources from which come new designs of products and services.

We in the United States are spending $17 billion for research and development to generate the knowledge upon which our military, our space effort, our health, and our economy depend—$4.5 billion being spent by industry for product and process improvement and the rest, $12.5 billion, by the government, as follows: $10.5 billion for the military and space effort; about $1 billion for health; and about $1 billion "for all other purposes," by the Federal Government. Of this billion dollars "for all other purposes," about a quarter of the billion dollars is spent for one industrial or economic purpose—that of atomic energy. About $175 million is spent to support the development and diffusion of agricultural knowledge through a mechanism involving the university, industry, and government. This mechanism of providing information to the farmer has been one of the most effective means of translating knowledge to use that the world has ever seen. For transportation technology, mostly aviation, the Federal Government spends about $125 million on research and development. To preserve and upgrade the natural resources of the country, its water and minerals, accounts for another $100 million. We spend $150 to $200 million for the basic science supported by the National Science Foundation. Only about $30 million is spent by the Federal Government to provide the unique technical information and resources that undergird our economy and our industrial development, other than these other very special programs.

Furthermore, the support for science and technology is not uniform. Three hundred companies perform 80 percent of the industry-supported research and development in America in manufacturing companies; 300 companies obtain more than 90 percent of the Federal research and development contracts. One hundred universities obtain 95 percent of the Federal funds for research. A few states obtain most of the research and development contracts that are let throughout the United States. Perhaps more importantly, during the last 10 years industry-supported research and development has grown very little. With the growing cost of technical work, it is becoming more and more difficult for the small firm or for the area of the country that does not already have technical resources to be able to obtain the technical information with which to develop further.

The countries that industrialize, that have the technical resources, tend to become richer, while those without them tend to become relatively poorer. Likewise, the regions of our country which depend upon a single product or a single crop and which have not developed the technical resources upon which a modern economy depends tend to become poorer.

Compare our investment in the technical resources directly important to industry with that of Europe. For the purposes of illustration, consider only the nonmilitary, nonspace activities. The nonmilitary, nonspace research and development of Europe exceeds that of the United States, even though Europe produces less than half our gross product. This is the decidedly appreciable technical activity which is pertinent to and available to the economy.

West Germany spends about twice as much of its work force on technical activities having to do with the civilian economy than does the United States. The nonmilitary, nonspace effort of most industrial countries of the world is doubling every 3 to 4 years, while that of the United States is doubling only in a period of 10 to 20 years.

This discussion has thus far concerned some of the needs of our society, of an urbanized life; the ability to translate technical resources to meet our needs; the function of engineering; and the availability of technical resources. But the most important element in growth is the entrepreneur and the environment in which he can flourish. There is only a little that the national government can do to provide an environment for risk-taking or incentives to start new enterprises. Industrial development is going to take place locally through the incentives provided by local communities. The modern entrepreneur or risk taker is one that knows not only a little bit about financing, something about the market, something about labor, and something about capital, but also knows the uses to which science and technology can be put.

This new entrepreneur is the exploiter of the technical resources of the country. To do so successfully, he must have a favorable environment to conceive the new enterprises upon which the local economy depends. I am not at all sure that our present patent system provides the maximum stimulation for invention and for the development of new technical enterprises. If an entrepreneur is to take risks with technical resources, he must be able to foresee profits. Certainly our tax structure could provide more encouragement to the risk taker.

It seems that a special effort is required by the Federal Government and by the state and local governments to stimulate the university to be much more closely in contact with the needs and requirements of the local industry, for it is truly a function of the university not only to educate the students who are there as young people, but to provide the education of the businessman and the worker in the benefits that science and technology can bring.

This administration has proposed a program called "The Civil Industrial Technology Program," which is aimed at stimulating universities to attend again to the technical work that undergirds the industry of the country and to stimulate state and local government and industry to match these funds to develop the local resources further.

I should also like to propose that something special is needed in each community. For example, perhaps the people of Oakland should consider the formation of a permanent group, a few people paid to work on the subject of resources for Oakland's future; to consider what has to be done to upgrade the labor force; to provide the technical advice to incoming businessmen; to tell new risk takers where they can raise capital for a risky venture; to provide the land and the resources which would make it possible to generate the new enterprises of the area. This special action is required in each of the parts of our country, particularly urban centers.

The technical resources of our country are now critical not only to the development of our economy but to our national security and to winning the game of space. They are crucial to the economic growth of less developed nations, of less developed areas, of less developed industries.

We must insure that our technical resources are conserved, are developed, and are used effectively, not only for our future but for the future of free men throughout the world.

If we know the needs, have the people that know how to meet them, have the technical resources, have a growing market, and have the environment that stimulates entrepreneurship, then the economy will develop and prosper. We will then be able to provide the basis upon which our national security and our space effort depend.

Chairman: **Jeffery Cohelan**
U.S. House of Representatives,
7th District, California

RESEARCH, EDUCATION, AND GOVERNMENT—A SPECIAL MESSAGE ON BEHALF OF THE STATE OF CALIFORNIA

Edmund G. Pat Brown

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CALIFORNIA IS PROUD AND HONORED to host such a distinguished conference. We are particularly proud that we should have it in the Congressional District of one of the truly great Congressmen, George P. Miller.

We want to extend a special greeting to you farsighted men from Washington whose thoughtful, and wise, and unimpeachable decisions have made California the Nation's leading state in the space age. We hope that you continue to decide where to build your space vehicles and do research work in the same impartial way, without partisanship and without bias. We would hate to think, and I speak as the Governor of our state, that our magnificent climate, beaches, mountains, and scenery might have influence on your decisions.

Let me just pause and tell you that the problem of being a governor is really a tough political challenge. I have a little grandaughter born in September 1962, and everything I do in Sacramento, in every message I deliver, in every decision I have to make, I try to think of how this state will be when she finishes high school 18 years from now. We will be a state not of 18 million people, but a state of 30 million people. It is not easy to get a sense of urgency either on the part of the people in government or the people that are as busy as you are in your own particular fields of endeavor.

This brief discussion concerns a problem of deepening interest and importance to all of us in this space age. Recently, on the campus of the University of California at Berkeley, Dr. Kenneth Pitzer posed the problem very concisely. He said that the challenges of the space age will be met only if we can solve the enormous problems of communications in a world that is becoming increasingly difficult to understand. He suggested that the scientist must know governmental administration and that the politician must become a scientist. This does not mean that the governor of your state should take up residence in a laboratory or that scientists should necessarily run for governor. However, it does mean that all of us must try to bridge the widening communications gap between laymen and the practitioners of space-age technology and research. A group of scientists in the Bay Area have already formed a Scientists' Institute for Public Information to promote this good cause.

This is not, I submit, the only communications gap in our country today. Nor is it the most serious.

Under our system of government, elected officials make policy decisions based on an expression of the will of the people. But policy decisions are becoming more complicated in our space age—not only in Washington, but in our state capitols and city councils as well. Too often we find the meaning of those decisions clouded or confused. Communications break down. Partisan and special interests distort the meanings. Emotional extremists with closed minds draw simple black-and-white solutions. These voices whine and whimper. They tell us that all taxes are evil; that big government is socialism—or worse, that it is communism; that you and I as citizens share no responsibility to help the unfortunate; and that it is no concern of ours that needy children and ailing old people deserve assistance.

In government, there is often a tendency to shrug off these attacks as the work of dissident minorities, not worth considering. But all over this state, school bond issues have failed because of the diligent hatchet work of these minorities. These minorities are suffering from the closed-mind syndrome—a sickness that I consider the most serious problem facing government today. It pervades all levels of society, and it takes many virulent forms. It is not confined solely to the John Birch Society, although I think that group is the best example of its sickest form. You see its mutations in hysterical attacks on the president of our state board of education, in demands by irresponsible political leaders that vital public services be slashed from governmental budgets, and in partisan outcries for illegal acts against Cuba which almost surely would drive us into war with Russia.

Some of these people cry out that government is managing the news. But it is not news management that our country suffers from—it is the mangling of facts and cynical partisan attacks on public policy which erode confidence in government.

California is a leader in the space age for many reasons, not the least important of which is the fact that we have one of the finest systems of higher education in the Free World. I ask scientists, engineers, and business executives a very simple question: Is there any way we can achieve our national objectives without massive investments in education and in top-quality governmental services? As a politician and as a person who realizes the burden of taxes on the people, I have searched to find some easy way. The answer is: There is no easy way. If we are to move this country ahead in the critical years before us, if we are to prove the superiority of our system over communism, we must adopt new attitudes toward government and its role in the free-enterprise society.

Those in the aerospace industry must also be on guard against the attacks from the fearful, the falterers, and the men of little faith. They are pioneering new territory. They are going to have to be prepared for a few brickbats. These attacks, when they come, should not deter industrialists from their goals; but industrialists cannot, and should not, ignore them. They must fight for what they believe is right—for that is the only way that people can get the facts on which to base the major decisions which must be made in this fast-changing world.

Aerospace industrialists are the leaders in the Nation's most advanced and most critical industry. On their decisions, successes, and failures, the prestige of the Free World is riding. As the President has said, we must "invoke the wonders of science instead of the terrors . . . to explore the stars, to conquer the deserts, to eradicate disease, to tap the ocean depths, and to encourage the arts and commerce."

It is not enough that only the missiles, the rockets, and the launching pads are built. Space must be explored, certainly—and America must lead the way, not follow. We must do these things partly to prove to the world that a society of free men, governed by law and democratic principles, is superior to the closed society of communism.

In California, we are proud that the aerospace industries are building many of the vehicles that take our astronauts into space. We will build many more of those vehicles and components here because we have created the intellectual and engineering centers and the business climate which have attracted the aerospace industry.

Those attending this conference know better than most men the needs of the space age in education, industrial development, manpower training, and a vital economy—and know how these needs must be met. They must be met in the legislative chambers of our Nation, our States, and our city halls. That knowledge and wisdom must be applied to help your political leaders reach a new American consensus based not on any narrow political grounds but on the broad support of an enlightened electorate. Help us communicate the true role of government and its objectives not only to serve special interests but to serve the public interest.

We must realize the goals laid down 2½ years ago by President Kennedy in his call to "struggle against the common enemies of man: tyranny, poverty, disease, and war itself."

Chairman: **Dr. Clark Kerr**
President, University of California

PERSPECTIVE AND OBJECTIVES OF OUR NATIONAL SPACE PROGRAM

James E. Webb

JAMES E. WEBB, Administrator, National Aeronautics and Space Administration; Member, Federal Council for Science and Technology; President's Committee on Equal Opportunity; National Aeronautics and Space Council; Chairman, Distinguished Civilian Service Awards Board. Formerly: Director, Bureau of Budget; Undersecretary of State; Vice President, Sperry Gyroscope Company; Practice of Law. University of North Carolina (BS, LLD); George Washington University (LLB).

I APPRECIATE, on behalf of NASA, the tremendous effort that has been put forth in this community. This conference would not have been held, in my opinion, were it not for the fact that Dr. Silver and his group at Berkeley started years ago to develop a competence which we are today—which we have been for several years—reinforcing. I believe the reinforcement that comes from this particular conference and the follow-on activities, in the years ahead, will be extremely important.

In his book, *The Brick Moon*, published in 1869, Edward Everett Hale wrote this:

> If from the surface of the earth by a gigantic peashooter you could shoot a pea upward from Greenwich, aimed northward as well as upward, if you drove it so fast and far that when its power of ascent was exhausted, and it began to fall, it should clear the earth, and pass outside the North Pole, if you had given it sufficient power to get half round the earth without touching, that pea would clear the earth forever. It would continue to rotate above the North Pole, above the Feejee Island place, above the South Pole and Greenwich, forever, with the impulse with which it had first cleared our atmosphere and attraction.

I think it is important that the human mind, developed in the great educational institutions of this nation, has long worked on the ideas that are now coming to fruition. Perhaps one of the most appealing images in the development of space concepts is that of Dr. Robert Goddard reading Jules Verne and making notes in the margin where Verne departed from important scientific principles. Verne came first, coupling brilliance with an active imagination. Goddard read science fiction, but he had the scientist's precision and the interest to record in the margin those things that were not reality.

Well, this conference is a reality. That so many national leaders in government, business, industry, and education found time to attend is a good omen that this conference may make an important contribution, that it may be a turning point in the Nation's consideration of ways and means to prepare for the twenty-first century, while making the good fight to solve our problems of urban living through use of organized facts, rather than organized prejudice.

The experience and the opportunity this first Dunsmuir conference has offered for exchange of views and ideas among and between you who are leaders in various segments of our national life has, I hope, been rewarding for all of you. But after observing the breadth and depth of your discussions here during the past three days, my own assignment certainly seems formidable. So if my remarks do violence to or repeat your ideas or those you objected to, please accept them as a statement of my own views regarding the problems and opportunities of this fast-moving, scientific age.

Wayne Thompson noted in a previous paper that in modern America urban life has grown to such examples of concentration as the Bay Area or, in the East, the almost uninterrupted stretches of city from Boston to Washington, which has come to be called the "Megalopolis." With this mushrooming and generally haphazard growth of our urban complexes bringing, as it does, a number of advantages and efficiencies, we have seen a corresponding growth in the ills which beset our cities.

All of us, whether directly concerned with the institutions we have set up to attack these problems or not, are often on painfully familiar terms with these ills, since we live with them from day to day.

Among them are downtown blight, the flight to the suburbs, the concomitant problems of commuting, juvenile delinquency and adult crime, the often ugly, sprawling, neon jungles on our main city thoroughfares, and the rise of mental illness, now widely recognized as caused more often by environmental stresses than by hereditary effects. These are but a few of the multitude of enormously difficult and interrelated problems involved in city life.

They are of interest in this conference which combines space, science, and urban life, because advances in science and technology are largely responsible for this thrust of urbanization. It seems appropriate, therefore, that science and technology should increasingly seek ways and means through which some of its effort may be turned in increasing amounts to helping solve the problems, urban and rural, which these changes are bringing about.

Our space activities and the program of scientific research in our generation have been discussed extensively in preceding papers. It is sufficient to note that science and technology will make it possible for us to explore the moon and eventually the planets and permit us to operate freely in the once forbidden and hostile region of space.

Let us consider, then, what the enormous thrust of scientific research and technological development needed to achieve these space objectives will also do for us—and to us—here on earth.

The following quote was taken from the George Washington Law Review:

> The transition we are witnessing is no equable transition of growth and normal alteration, no silent, unconscious, unfolding of one age into another, its natural heir and successor. Society is looking itself over in our day from top to bottom, is making fresh and critical analysis of its very elements, is questioning its oldest practices as freely as its newest, scrutinizing every arrangement and motive of its life and stands ready to attempt nothing less than a radical reconstruction.

This quotation is so pertinent as an assessment of this age in which we live that it may be surprising to learn that it was made by Woodrow Wilson in an address to the American Bar Association in 1910. That Wilson's thesis remains so appropriate after the passage of more than half a century is in itself a tribute to its wisdom. The point he was trying to make was that there are moments in the history of society when normal methods are not sufficient, when the legal rule cannot gradually adjust itself to the historical fact, when legislative programs are sought as the fastest way to adapt the legal system to social need, and when social habit is replaced by discussion, by political contest, and by political action.

In Wilson's day the idea was associated with the effects of the industrial revolution, the changing relationships between capital and labor, but today it applies with equal force to the impact of a newer revolution, the impact which science and technology are having upon society. The forces of change in the first half of this century were very great, as were the social and economic upheavals which they produced, and the legislative reforms which were established to deal with them. But all of this has been transcended by the accelerating forces of change of the day in which we live. Today we are dealing not only with the profound change in the social and economic structure of the country and the world, we are dealing as well with an even more profound change in man's own conception of the boundaries and the limitations of his habitable environment and his understanding of the forces of the universe.

Bergson's idea that men are habituated to think of the moving only in terms of the unmoving is giving way to a generation able to conceive of itself as a part of a dynamic universe. Man is no longer rooted to terra firma, to his native land, or to his city block, either in the literal sense or in his understanding of the powerful forces of the universe of which he is a minuscule part. Increasingly he comprehends that the new understanding and knowledge which are being unleashed by science and technology will alter his existence in more ways and more rapidly than he can possibly foresee. And while he may fear these changes in relation to his own ability to adapt himself to their consequences, he anticipates them with some eagerness, as well, because he is surrounded by ever present evidence of the benefits he has already received from the scientific and technological progress of the past.

Within our lifetime, science and technology have caused ancient economic, social, and political concepts to become obsolescent at a pace that matches that of the physical fruits of research and development. The automobile and airplane have given us convenient transportation, but they have also altered our whole concept of the world in which we live as it relates to our daily lives—and so with radio, television, and countless other developments.

Man has gained mobility; his horizons have broadened, not only in the geographic sense, but because he no longer feels bound by family, farm, or traditional village industry or nearby city factory. He feels no constraint to farm in Kansas, or mine coal in Pennsylvania, or work in a particular city factory simply because that is what his father did, and perhaps his grandfather before him. Frustrating as the problems created by this mobility have become, man has been so adaptable that as science and technology have reduced the employment potential of mining coal or planting wheat, or weaving textiles or cutting metal, new opportunities have opened up. The technology that has diminished some traditional human roles has replaced them with new, more fruitful occupations. But, particularly in our cities, we face the hard fact that large-scale educational and training opportunities to qualify them must somewhow be provided.

As in the past, accompanying the visible products of man's advance are vast social, political, and economic upheavals. The theme of this conference is that a civilization which can move with serious purpose to gear itself for travel to the moon and the planets will not be content with old and outmoded socioeconomic concepts. Every thread in the fabric of our social, political, and economic institutions is being tested as we move into space. Our economic and political relations with other nations are being reevaluated. Old concepts of defense and military tactics are being challenged and revised. Jealously guarded traditions in our educational institutions are being tested, altered, and even discarded. Our economic institutions—the corporate structure, itself—are undergoing reexamination as society seeks to adjust itself to the inevitability of change.

The changes which are driving men from farm to city have aroused deep and serious concern at both ends of the scale. While urban planners wonder how they will cope with too many people, agricultural regions wonder how they can survive with too few, and both seek ways to retain the new generation which are their greatest hope for the future.

Recently on a visit to several Midwestern states, all of them in varying degrees confronted with the consequences of mechanized agriculture and an obsolescent or underpotential industrial pattern, an elderly political and business leader, who once participated in the creation of a prosperous economy in the area, said with some sadness, "It is sobering to realize that a state which once attracted the most imaginative, energetic, and courageous of the nation's young pioneers can no longer even retain the sons they have produced." He went on to say that unless we find ways of adapting to a changing world, this state will become "a slag heap of nostalgic old men." That seems hard to believe and it is an overly pessimistic view, but it does illustrate an area of great socioeconomic concern.

What are the lessons to be learned from this view of things? How may we act to insure that the continuing expansion of knowledge, the accelerating rate of technology progress, will continue to be a boon to mankind and not a burden?

Consider two needs which are of critical importance. The first of these is the need to create favorable conditions compatible with the American private enterprise system through which the knowledge which we gain and the skills which we develop in our huge program of federally sponsored research and development—programs for which President Kennedy has requested almost $15 billion for fiscal year 1964—are identified and made available for use in the industrial stream to contribute to economic growth and to our nation's power to survive in a world where second best is more severely penalized than ever before.

The second need is closely interrelated with the first. It concerns a necessity for developing viable relationships among science, education, industry, and government. These are necessary to utilize research results for productive purposes, to create the legislative framework needed to meet needs of our time, and to bring into effective use the wisdom of the economists and other social scientists. How can today's businessman learn as much about scientific discoveries and new technology as his father knew about steel?

One obstacle in the path of prompt application of today's research is the extent to which scientific effort has gone beyond the experience of most citizens. Therefore, in the Space Agency, where our specific responsibility is the achievement of United States goals in space, we are at the same time not unmindful of the fact that the applicable knowledge gained must be utilized to further economic growth. And we recognize that the potential multiplier effects of our vast and complex researches will not be quickly realized without something akin to Woodrow Wilson's idea of radical reconstruction.

How does such a radical reconstruction take place? How can we do our part as citizens and leaders of thought and action to see that they go far enough but not too far?

In the preceding paper Governor Brown says that under our system of government, elected officials make policy decisions based on an expression of the will of the people. But policy decisions are becoming more complicated in our space age, not only in Washington but in our state capitols and city councils, as well.

Governor Brown quoted an idea Dr. Kenneth Pitzer expressed at the University of California recently that the scientist, or some scientists, must know governmental administration and that the politician, or some politicians, must become scientists. It seems to me that Dr. Pitzer has extended this idea by pointing out that in the great mobility of our society, men can have more than one profession. Men can move about. This is not true in most other countries. Here, a person who has been a politician can become a scientist. It seems to me that this is a very important consideration where vast quantities of talent are no longer required in active service after retirement age. (I mean active service within the structure that provided the retirement.)

Furthermore, how can the will of the people, or a viable concensus of it, cut through complexity and find some solid basis for continuity, for fixation on something better than a status Congressman Miller called "more antiseptic and with greater leisure than has ever been known before."

This status is not enough. Congressman Miller pointed to our history as one guide in this quotation:

> It has long been acknowledged that our technological leadership of the free world is based on an unmatched ability to translate into practical terms the results of research. There is no doubt that this is our special forte. It has been a unique force in the hands of our people. It has been the imprimatur of progress and dynamic energy. It has supplied a momentum to our society that has carried this nation through vicissitudes that have perverted or destroyed nations of our times and of the past.

Congressman Miller went on to give this credo that I think is extremely important in the basic idea that will emerge from this conference:

> Our problem, then, is to maintain that momentum, to preserve the strength of that unique force, through those who will come after us. It is our task to make sure that our scientific research will continue to serve the needs of the world.

Now, much skepticism has been applied to the existing or ad hoc forms of organization for performing this task set by Congressman Miller; but Dr. George Simpson has pointed to one way out, a way that should certainly be carefully considered by those who will be seeking what we now call "new organizational concepts." It is the concept that we need, in his words, "a trusted link between the laboratory and the public."

Consider Governor Brown's "will of the people" in the light of Simpson's statement that where we are dealing with great masses of people, we must create confidence in our sources of information.

How can the multidisciplinary flux of a great university become a source of information in which leaders in all walks of life and large numbers of citizens can feel a flow of confidence? Can it maintain its basic integrity, its laboratories, its education, and its atmosphere that fosters creative ideas that do not stem from laboratories and still play a larger role in supplying a trusted link between the laboratory and the public?

Dr. Silver has spoken eloquently for the caution that should be exercised in even suggesting and most certainly in implementing a new or expanded role for such an institution as the university. He has stated clearly the fact that university personnel do respond rapidly and effectively in areas where responsibility is seen, but he has also clearly indicated that the process through which new insights are generated embodies far more than mathematical analysis or reproducible experiments, and that any forced diversion or dilution of this successful process has grave danger.

Where does this leave us? Are we to accept the recent statement by the Director of the Peace Research Institute, Dr. Donald Michael?:

> It is known from the history of innovations that the eventual impact of technological developments depends more on the surrounding economic and social context and the prejudices and the predilections of the decision-makers in this society than on the logical potentialities of the innovation itself.

Now, if this is true, can the university provide a linkage to logical potentialities as a force to counteract prejudices and predilections?

In the Bay Area, in Oakland, a continuing effort is going to be made. As Wayne Thompson has said:

> For some years now the preponderance of the nation's scientific talent . . . has been directed to solving problems of national defense and space research. It is our hope that we can direct a good proportion of this scientific information to solving our urban problems.

The significance of that juxtaposition of words, scientific *talent* directed towards defense and space research, scientific *information* to solving our urban problems, should be pondered.

Leaders of this conference have pledged a continuing effort in this area; we can have confidence that they will proceed in the spirit of this quotation from Arthur Clarke, written in 1959:

> By providing an outlet for man's exuberant and adolescent energies, astronautics can make a truly vital contribution to the problems of the present world. Space flight does not even have to be achieved for this to happen. As soon as there is a general belief in its possibility, that belief will begin to color men's psychological outlook.

In many ways the very dynamic qualities of astronautics are in tune with the restless, expansive spirit of our age and I have no doubt that this continuing effort in Oakland will proceed, not despite of but because of the new cosmology by which Von Braun and Van Allen, Pickering, Dryden, and Jastrow have suddenly expanded man's domain from this planet earth to a whole solar system; this cosmology has sown the seeds of a dynamic revolution in man's conceptual relationships.

Think of this: 10 years ago, utilizing an aeronautical technology which could exploit the atmosphere only up to twice the height of his mountains, man grappled with a shrunken and bipolarized world. Less than 10 years from now, he will have stood on the moon and surveyed the earth, while confidently preparing a voyage to nearby planets. In this decade the ideas developed at this conference will produce a better quality of life in California, in the whole of the nation, and, hopefully, in the world.

SEMINAR SESSIONS

SEMINAR A

What Scientific Developments Will Affect the Transportation, Communication, Power Resources, and Construction Industries in the Years Immediately Ahead?

Chairman: KENDRIC B. MORRISH, Vice President and Manager, Wells Fargo Bank, Oakland, California

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PRESENTATION BY

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WHAT SCIENTIFIC DEVELOPMENTS WILL AFFECT THE TRANSPORTATION, COMMUNICATION, POWER RESOURCES, AND CONSTRUCTION INDUSTRIES IN THE YEARS IMMEDIATELY AHEAD?

Dr. William O. Baker

I have no formula from which to derive the effects of science on the industries of transportation, communication, power resources, and construction in the immediate future. However, certain limiting conditions can be set immediately. For instance, unless there are progressively improved techniques for translation of the discoveries of science into usable and practical forms, there will be no effect. Further, unless there is a suitable national policy which recognizes the increasing difficulties of innovation in the large systems that are typical of such industries, the effects of scientific developments will be small.

However, *lower* limits are not the theme of the conference, whose goal is to "consider and evaluate the application and relevance of new technology to the needs of industries and cities. . . ." Nevertheless, in seeking *upper* limits, it is necessary to choose both the content and the tactics of science which are central to these new aspirations.

QUALITIES OF SERVICE INDUSTRIES AFFECTING PROGRESS

The great organizing service industries under discussion here all possess certain qualities in our nation which make scientific evolution in them virtually unique in the world; namely, they are all still basically free enterprises operating in response to the public will and with high conscience for the public welfare. It is true that the construction industry is less clearly identified with this remarkable role of private resources serving the public purpose than are the others. But even there, with public construction, including roads, dams, airports, and so forth, the position of the private operator is still vastly stronger than in any comparable society or nation elsewhere in the world.

In the other cases, particularly those of railroad, airline, automotive, telephone, telegraph, radio broadcast, and TV broadcast systems, and electric and fossil-fuel resources, our private systems stand in dramatic contrast to the usually nationalized or state-operated systems of the rest of the world, including Free World areas. While we are all gravely concerned about the forces in the world which may tend to collectivize our operations in the years to come, it is, nevertheless, an illustrious facet of history which shows most of these industries in the United States now responding alertly and adroitly to scientific progress, and, indeed, in many cases, contributing to such progress.

Included also are the relevant industries which are the larger developers and suppliers of the systems components in transportation, communication, power, and construction. In some industries, such as transportation, there has been an unfortunate division between the components suppliers and the systems operators. Hence, while the automotive firms have vastly improved diesel and electric power for the railroads, there has not necessarily been a corresponding increase in the effectiveness of the systems technology. A similar situation is seen in many aspects of the construction industry, where the component suppliers, including chemical, metallurgical, and material manufacturing sources, have kept at the very forefront of modern science but systems operators—the assemblers, building trades, and even architects, to say nothing of regulatory bodies—have not supported most efficient assimilation of these components into systems of new structures.

On the other hand, in the power industries, the components resources—the makers of boilers and other energy converters, turbines, generators, distributing equipment, appliances, and so forth—have largely, on their own initiative, kept close to the systems engineers and operators, that is, the electric utility companies. The generally excellent results that accrue are noted subsequently. In the communication industry, it has so far been largely possible to integrate the research components developers and manufacturers directly with the systems operators, as is seen in radio companies, such as RCA, with their manufacturing and broadcast activities, the telephone companies, such as General Telephone and Electronics, with its Sylvania manufacturing branch, the Bell System with the Western Electric Company, and others. Here the efficiency and responsiveness to human and public needs seem to be the highest, and it may be that the demands of modern society for use of science and technology will require more and more of this kind of integration.

RELATION OF NATIONAL SPACE GOALS TO INDUSTRIAL SCIENCE

It is necessary to review the structure of the service industries in order to see what the meaning of new science and technology in relation to our present great national goals in space exploration and other technical domains may be. The origins of those goals may lie in very basic concerns such as the national security—the ability to meet threats and challenges in space about our globe. It is unlikely that the national aspirations in space have been selected as the way to advance directly the science and technology of the public service and private industries. Also, there is little experience yet to show that incidental effects of great national programs such as space and nuclear energy have any profound influence on the general advance of national product or wealth. Indeed, we could hardly expect this to be otherwise since, on the whole, our federal missions for nuclear energy and space exploration are managed skillfully to attain specific objectives such as nuclear weapons, nuclear propulsion for submarines, lunar exploration, and the like.

Thus, there will not be a loose spillage of these efforts and results into other main channels of industry and commerce. Presumably, the better the management of these missions, the less the byproduct that emerges casually in the form of commercial technology. This quality of modern science and technology is probably not yet well understood, since in an earlier part of this century it was fitting and fashionable to emphasize the unity of knowledge in technology as well as in science. In the meantime, however, and even just during the past decade, the accumulated knowledge about each of several different technologies has become so large that practical transfer among them is increasingly inhibited.

However, there does seem to be a deep coupling of the major forces of our space program with the most central needs of our society. This can be shown in respect to the transportation, communication, power resources, and construction industries. This coupling is through the *expectations* which space systems and programs represent to the people of our nation. Thus our people see, first, that our national leaders bespeak expectations from science and engineering beyond those ever realized before. Then they see our national abilities, led by scientists and engineers, turned actually to achieve many of those seemingly fantastic expectations. Manned space flight is probably the classic example, so far, of this national gaining of the "insuperable." Here is seen, indeed, a very subtle quality of the Free World's approach, even in the formulation of these expectations, in contrast to the approach of other societies. We have been criticized for announcing beforehand our expectation of space achievements, particularly of manned flight, and most recently of lunar voyages. Our habits are in striking contrast to the practices of other nations, whose achievements in this field have been announced only after the fact.

It is true that exercising such restraint is a conservative and certainly canny way to play a cosmic and costly game. On the other hand, if, indeed, the aspirations of man in science and technology are to liberate wellsprings of human energy—as in the great cathedral building waves of the Middle Ages or the oceanic explorations of a few centuries ago—is it not wise, and also just, to have the detailed nature of science and engineering behind these feats laid out as great expectations beforehand? It is experience with these new dimensions of expectations by our people and the reasonable achievement of such expectations in such domains as our national space program that will, in fact, have the most profound influence on the role of science in other and perhaps even more vital affairs. It is in this context that I would like to suggest the effects of expectations on scientific developments in industries that will be central to progress in regional and urban wellbeing and advance in the years ahead. I can speak of such expectancies with both conviction and feeling, as a scientific worker as well as a citizen. Indeed, already the superb achievements of the Mercury-borne astronauts, announced as expectations beforehand, as well as a more intimate association with the expected behavior of ablating heat shields for their reentry, have been stirring events. The expectations of my colleagues and of my industry for the first-time success of the Echo and Telstar satellites, and even the 99 out of 100 shot reliability of our radio guidance for space launchings by the Thor-Delta rocket systems have influenced our much broader expectations of what science and technology can do.

SYSTEMS TECHNOLOGY COMMON TO SPACE AND INDUSTRIAL OPERATIONS

Why are aspects of operations in outer space so prominent in our foresight about the industrial strength which must underlie urban welfare? This is because the industries involved in urban support—transportation, communication, power resources, and construction—are composed of large technical systems. They cannot be either advanced or best directed by any single miracle of discovery, although such things as electrically superconducting metals would have profound and widespread effects, as will be discussed subsequently. Thus, on the whole, what is required most for progress in these areas is a progressive set of expectations, very great and very brave ones, that will challenge the scientists and engineers of these enterprises and of our national community to do the best things for each of them. To the shape and scale of these challenges our space program, for the reasons noted above, can contribute strongly. Indeed, this has already been seen in the communication arena, in which Dr. John Pierce's concepts of the meaning of space capabilities for satellite communications have already rereceived wide confirmation, although by no means industrial or economic verification as yet.

It has seemed necessary to prepare in this way for the views to be developed on opportunities and effects of science on urban service industries, because references to the substance of such scientific change in these industries will have to be compact. The worthy issue is the range of scientific possibility that applies in each industrial area and might be realized if the right expectations are directed toward it. Our experiences with the space programs should teach us much about that, too, for they have already reminded us how steep is the path toward realizing great technical hopes.

Further, the expectations for these industries will have to be met with care about economics, capital requirements and, basic to all these, profits. It is always interesting that the great diversity, the choices, the options that are provided to man by modern science and technology have actually made true profits one of the most valuable and essential gages of social progress. Thus it used to be that the profiteer was associated with control of vitally needed or wanted things or services, such as a single antiseptic drug where there are now hundreds of such drugs, a high-speed rail transport route where there are now highways, canals, airlines, and pipelines, or a particular silk textile where there are now dozens of synthetic equivalents and alternatives for silk. Now, on the other hand, society chooses, often with the sure touch of mass preference, to get from among many the particular type and quality of goods and services it wants. By its willingness to pay and to provide profits in this way, society stimulates the emergence of the best and the most effective. This process, subject of course to exceptions and to the scoffs of the cynic, still seems to be the greatest hope for the proper selective use of science and technology in the national interest. The American people seem to have a shrewd realization that this is a good tactic for the wisest exploitation of technical discovery and engineering. These policies must be accepted governmentally and politically if there is to be progress in the great urban complexes which are emerging, and wherein especially there is a temptation to collectivize and to ignore the selectivity and thrust toward quality provided by a responsible profit system.

Thus, in this sense, there are many analogies between the problems of urban development, which are practically the problem of social development in our day, and those of space and other heroic technical ventures. As noted, however, there is also a challenge common to the two domains: that of needing every possible skill in converting new science into new technology and engineering. The details of the approach may differ strongly in the two fields and will certainly differ very strongly from the national space mission insofar as the industrial support for urban development, even in the service industries under discussion, follows the free-enterprise private-initiative pattern. Yet we have always to keep in mind *in both* the decisive value of choosing the right developmental and engineering approach. Because this feature is so important and because each industry must develop its own schemes for assimilation of new science (with full account of some of the basic differences among the industries we are considering), the technological impacts in the years ahead should be considered specifically in terms of the particular industries. Thus, we can be consistent with our guiding theme of great expectations which should be developed for each of these industries, but whose realization will, of course, be controlled by a common tide of scientific finding and application which spreads increasingly into all national affairs. Now a few comments will be made about possible relations of each of the four industries to the main currents of knowledge to be noted.

PRINCIPAL AREAS IN SCIENCE AFFECTING SERVICE INDUSTRIES

Two arenas of science now appear to stand out in their import for transportation, communication, power resources, and construction. These are the sciences of *computers* and *materials*. As stated in the report of the Engineering Research Committee (Assistant Secretary of Commerce J. H. Hollomon, Chairman) to the Engineers Joint Council ("The Nation's Engineering Research Needs 1965–85"), high-speed computing machines are not only revolutionizing business, scientific, and technical handling of data, but more dramatically the handling of information itself. Following this report, the Engineers Joint Council has undertaken an extensive national program to display, and perhaps to influence by education and research, the nature of the revolution in engineering which is underway. While many elements of this revolution are already well known, design automation and simulation are two areas of pervasive importance. Design automation has recently taken a sudden leap ahead, so that it is coming out in a different form than the production of alphanumeric design data which were traditionally transferred manually to drawings for production use. Nevertheless, it is striking that even this earlier rudimentary form was of high value for the creation of transformers, certain electronic power supplies, heat exchangers of standard configurations, and a few other products, even 5 or 6 years ago, as noted in the works of S. B. Williams, J. B. Allured, J. Nieberding, and their respective coworkers.

IMPACT OF COMPUTER SCIENCE ON BASIC INDUSTRIES

Now, however, as shown by T. H. Crowley, certain functions of the design and manufacture of systems can be accomplished completely by general-purpose digital computers. These principal functions are (1) optimization of parameters, (2) preparation of manufacturing information, (3) control of processes, and (4) administration of production and product distribution. These schemes are on the verge of recasting the whole method of component production in industry. Likewise they permit spectacular efficiencies in systems assemblies of the systemic industries under consideration.

It should be recalled that these effects have been possible only through the instrumentalities of high-speed digital computers whose success is, on this scale, essentially dependent on modern solid-state electronics. This is derived mostly from the transistor and other semiconductor devices but also has large support in rapid-access memory involving the latest arrangements of magnetic cores or drums. Thus, we are discussing implicitly the very forefront of modern physical science, of electrons, waves, and crystals. In this regard it is most instructive to recall that virtually none of these vital ingredients for information handling and data processing came from specific missions of the computer business or, indeed, from the gigantic military projects dependent upon electronics (radars, command and control, sensing and data processing, fire control and guidance systems, navigation and signaling, air defense and traffic control, etc.). Rather they arose from fundamental studies in industries whose life currents depend on knowing about the properties of electric charges and waves. These were the radio, power and control machine, and communications industries. From these came the vacuum tube, the transistor, the high-speed diode, the traveling wave tube, the backward wave oscillator, the ferrite magnet, the solar battery, the optical maser (and the realization of the microwave maser), and many more.

Examples of optimization can be multiplied vastly through the industries noted. Above all, they will be important ingredients in the great expectations for expertly designed systems for highway and rail traffic flow, for mobile communications, personal video, and special voice or record message service. Such analyses will be needed for versatile fixed and mobile power systems and for construction techniques and modules that will serve more fully the needs for buildings and public works.

These computerized methods have already been applied to the preparation of detailed information on the design and output of logic circuit packages, including even such equipment engineering problems as ways of mounting the packages and where and how they will be interconnected. While this verges on von Neumann's grand vision of the self-generating automata, it is also a highly practical method of detailed design which, because of the volume of units involved, has been up to now a large burden or restraint to economical manufacture. Indeed, the Western Electric Company is now producing such logic circuit packages from design and manufacturing information achieved by machine. The designs and locations of components on the chassis are first worked out with specific programs. Then lists of materials, wire run lists, and drawings, including logic diagrams and wiring diagrams, are stored on magnetic tape and also printed out for direct checks. This has now been advanced through the work of Crowley, Rosenthal, Herbst, Leagus, and others so that direct output of punched cards or tape for control of wiring machines is obtained.

A recent application has been described by Linderoth for similar design and production of machine-tool parts. We can expect here an economy, reliability, and precision of mass-produced components never before achieved. All the industries cited have large ingredients of highly repetitive operations such as coil making, control wiring, control of machine parts and casting in automobile manufacture, use of sophisticated distribution systems for power grids, and the infinitely repetitive elements of enclosures, fastenings, service, and so on, in construction.

RELATION BETWEEN DESIGN AND PROCESS CONTROL

A striking feature of this manufacturing information regime by machine is that many elements that have normally been considered to be process controlled, such as the adjustment of a machine when it is tooling parts, can now be included as preliminary manufacturing information instead. Accordingly, the whole scheme of production engineering is modified. Obviously there are strong interactions here, in design and manufacturing precision, with space technology activities and, as these progress, more and more high expectations arising from them can be transferred to invigorate production methods in other areas.

In spite of the improvements in manufacturing information which reduce the need for detailed process controls, the latter remain central ingredients of efficient production. The principles of automation and feedback control, derived from the work of H. S. Black, the discoverer of feedback, L. A. MacColl, and others, formed a base for automatic control mechanisms. From the same base, in the same laboratory, has grown much of the guidance and flight control of missiles, rockets, space launchers, and space vehicles. Thus, again, the scientific disciplines of electrotechnology, especially from communications and electronics industries, have linked back to space operations. Darlington's essential guidance and navigational methodology, which was itself the forerunner of interplanetary navigation systems, derived from the communications circuitry and philosophy. These have now branched also in other directions to automata and control. Existing and forthcoming operations of process control include the whole materials supply backup for the industries we are reviewing, especially in chemistry and metallurgy, but particularly also the energy release methods for the power resource industries. Thus, both the petroleum extracting and refining industry itself and the fixed power supply business are sharply dependent on electronic control systems.

Particularly for this reason, although also largely because of improvements in design and materials as will be emphasized again later, the electric utility industries advanced from requirements of about 65,000 Btu/kw-hr 80 years ago to 8,600 Btu/kw-hr now, reflecting the result of detailed process control for the manufacture of electricity. This is shown even more concretely in terms of local coal consumption (where again materials and design have also had a high part), which even 10 years ago was about 1.14 lb/kw-hr, but last year was about 0.85 lb/kw-hr—down about 25 percent in a decade, even though it represents one of the oldest operations in modern industry. The national saving here of about $500 million annually in fuel consumption has high import for the urban complexes of the future. Again, however, this is a place for exercising high expectations. These are even reflected by the cheerful courage of the power equipment industries in designing the present boiler units to produce a kw-hr of electricity from 0.72 lb of coal. (Of course, elementary thermodynamics indicates that this is by no means a final limit.) Thus, process control is, like space exploration, still in its infancy.

With respect to construction ingredients, it is remarkable that a large cement factory in Japan has computer process control for most of its operations, including those of the kiln.

MECHANIZED INFORMATION HANDLING FOR PRODUCT CONTROL

In the administration of production and product distribution, the computer techniques are relatively far advanced. They apply to all industries we are discussing, and include particularly inventory control. Here, they can effect an optimum between an inventory large enough to prevent delays from lack of material and one which is overcostly because of oversupply. For the administration of output that has job shop characteristics—including particularly the components of the construction of buildings, but also the assembly of machines for transportation, power generation and usage, and communication—very complex schedules can be administered through machines. Automobile companies are even controlling their warehousing as, indeed, are other basic industrial suppliers, including communications and power suppliers. Reports obviously can be and are being prepared swiftly and (sometimes) concisely through machine tabulations and data analysis. (Modern machine methods make these reports so abundant that they may become the next dangerous oversupply, rivaling agricultural surpluses.)

The implications of these automated methods for urban development through the industries cited are immense. For instance, the time required to introduce new designs of transport vehicles, power-distribution schemes, or construction systems can sometimes be reduced severalfold by these methods. Plans for public works, which might otherwise take several years to achieve, may be expected in the future in weeks or months. Therefore, the whole time scale of planning, financing, and executing such public works, communication systems, and power systems can be much shorter than the decade or so now often involved. Similarly, these computation techniques in the methods just reviewed, but also involving those of simulation and analysis of design, especially when coupled with an increasing role of new materials (as will be noted later), can be expected to reduce failures. Incidentally, large commitments to public works such as bridges, roads, tunnels, power lines, and the like, can be made more deliberately because of enhanced planning skills. Costly maintenance of poorly designed highways, the collapse of bridges and premature aging of buildings, and the inadequacies of communication and transportation systems will be drastically reduced by computational conveniences and the extensive handling of statistical information by high-speed machines.

These are not easy or simple advances. We have no "thinking machines." The present logic aids themselves demand high expectations and very high skills. However, as space science has demonstrated for some other cases, mechanized information systems are possible. In the course of achieving them and of shaping our expectations for them, we may accomplish also some other things of comparable value.

EFFECT OF COMPUTER TECHNIQUES ON STATUS OF ENGINEERING

It has been said that the space program has diverted great numbers of students from undertaking engineering and other cardinal learnings in favor of supposedly more glamorous "space sciences." In fact, however, we are sure that engineering in its older forms has expectations too low to challenge the young minds of the quality that this nation must attract to its industry and government in the future. Thus the logic machine methodology will, in fact, liberate large numbers of the more than 600,000 engineers presently employed in industry from the narrow and tedious repetitive operations to which they have been too much committed. It will restore to engineering the excitement and personal independence with which it was so vividly animated in the early parts of this century. Thus, we can expect an attraction of good minds into these industries (as well as into the space projects themselves) to do engineering tasks supported by scientific computer resources, in proportions which we have so far failed to achieve from our expanding population of educated people in the past decade.

The impact of mathematics on a broad range of industrial operations, including new statistical methods as embodied in high-speed computing machines, has been discussed with a mere hint at some of the most appealing of these opportunities. These are in the field of simulation and systems analysis. There is a natural connection with space operations here, since the inaccessibility and difficulty of experimentation in outer space, with its dangerous detachment from human environment, require extensive simulation of most effects on satellites and their contents. It was found—largely by machine experiments simulating communication qualities such as voice transmission and traffic patterns—that massive experimentation with models could be performed in which everything existed only within a computer program, which would then yield "experimental" data. These findings are being progressively coupled with operations research and statistical studies. Thus, we can expect to know a great deal about elaborate plans for transport systems, communication networks, power generators and grids, and even highway and perhaps building qualities before experimental physical models are made.

The citizens who support and the administrators who direct large programs for urban services, which are usually implemented through the industries we are describing, should count among their great expectations vastly more precise estimates of costs and performance than ever seen before. More sophisticated mathematical modeling, coupled with computer solutions such as those done by the Brown University group of Prager, Newall, and their coworkers, has given important insight into designs of tunnel, city street, and traffic-control systems. We can expect continued improvements here.

NUCLEAR POWER AND CIVILIAN SCIENCE

Our views of the role of great expectations in coupling science with industry, of course, cannot ignore the civilian nuclear energy history. Even the November 20, 1962, report of the Atomic Energy Commission to the President on "Civilian Nuclear Power" left unclear the role of private and public utilities. The AEC felt it needed to provide 10 or 12 power plants of improved design, but there was no conviction that these would be economic or compatible with the profit-making responsibilities of the private power industry. Nevertheless, the report asserts repeatedly that all aspects of the atomic power industry should be shifted to private enterprise "as soon as possible" and, indeed, recommends legislation permitting private ownership of special materials. We have seen here a confusion of the expectations of scientific discovery, which has been expertly sponsored by the AEC, with the coordinate but separable problem of application for economic service.

These roles must be separated soon. This particular report of the AEC illustrates, for instance, the sort of progress that can come from independent, economically energized efforts at the application of basic nuclear science. For example, the spectral shift nuclear reactor, developed independently in the Babcock and Wilcox laboratories, was noted to be of special appeal for exploitation of the vast thorium reserves, since it would work particularly well for the thorium-uranium cycle. The whole matter of advanced converters or fast breeder reactors is recognized to be of special industrial importance. But failure until now of adequate systems research and analysis of the role of nuclear generators in the whole electric power industry has made this not only nationally but internationally one of the dark chapters in the applications of science. The simulation and computer-based information analysis schemes under discussion might have helped in this matter some years ago. Indeed, in a recent reminiscence of the outlook of physicists when the Fermi pile began to operate in Chicago, Professor Wigner sagely asserted that they were completely misinformed about the power-generation problems, even in their concept of how large an element of the national product was involved, but more particularly as to the advances in nonnuclear sources which were then coming into being. A definitive report of 1962 asserts that the use of coal is still rising rapidly and will not drop off because of supply and other economic factors until about the year 2000! This is far from the opinion that was general in the late 1940's, when nuclear power and uranium stocks were the portfolio darlings.

The power-resources issue is indeed a good one for much more extended applications of computer analyses and systems simulation than has even now been attempted. A current report from the National Academy of Sciences to President Kennedy (January 1963, M. King Hubbert, Chairman) states that oil and natural-gas supplies are now expected to be 80 percent depleted in the next 80 years. Similar warnings have been advanced for many decades, and also we know of oil shale and other reserves that have been unknown in the past; nevertheless, we still need (and the power resources industry should promptly seek to acquire) penetrating analyses of systems for mobile power generation as compared with those for fixed power generation.

It may be that our resources for fixed plants, such as the electric-power generators, need few immediate supplements. (This report suggests that 90 percent of the U.S. coal supply will be used up only by the year 2400.) However, the situation for mobile, especially automotive, power, which couples also with the transportation industries problem, is much more uneasy. In fact, while in 1920 gas and oil supplied only 8 percent of the total energy used in the United States, both fixed and mobile, in 1960 the figure was 73 percent and it is still climbing rapidly. (We can also get inadequate comfort from consideration of world resources of oil, since the belief that 80 percent of ultimate reserves will be used by the year 2040 applies to world resources.)

The discussion of these familiar issues is not intended to stress the appeal of using some of the 10's or 100's of millions of metric tons of rock containing uranium or thorium. (When these exist in amounts of 50 grams or more per ton, we already have in the United States hundreds or thousands of times more potential fuel than the world supply of fossil fuels.) Also, the present purpose is not to emphasize the opportunities of using nuclear energy as a chemical resource for making gasoline or oil or other liquid fuels by hydrogen reduction of carbon compounds, or the like. Rather, it is a plea to supplement the decision making and analytical processes of man's brain with the immense power of modern information-handling systems so that really wise and valid plans can be made now—in time for what may be future crises in power and transportation services. The magnitude of the space program has already induced the management of the NASA to undertake extensive systems studies such as are represented by their own directorates, by the General Electric operation on reliability and tests, and by the Bellcomm operation on manned space flight. It is unnecessary to emphasize that what we are discussing in all these cases up to now is far beyond the usual Critical Path method or Pert method of project accounting. These latter are simply ordinary project schedule and ledger schemes that have been mechanized and improved for large programs, but they are only a small component of the sort of information processing that we are considering here.

NECESSITY FOR SYSTEMS ANALYSIS IN NUCLEAR POWER PROGRAMS

Are we not reflecting some of the maturing of the Age of Science when we ask for wiser thought and action about what we have, rather than relying on the headlong search of recent decades for some miracle solutions or for massive, brute-force finding of what we do not have? Indeed, this latter attitude seemed to be the cause of many of the lost years and spent billions of nuclear power effort since 1946. Similarly, the more than $1 billion spent on nuclear-powered aircraft (ANP) is very largely a monument to inadequate systematism and materials resources. Over and over, the 14 separate review groups operating in the period 1955–61 made recommendations consistently focused on inadequacies of project organization and of materials for critical functions in that project. The official report of the Comptroller General reviewing this program showed that decision-making between the AEC and the DOD, involving important technical points, sometimes took more than 2 years on a single issue! Lack of knowledge of the performance of materials as well as inadequate choice of alternatives were major deficiencies.

In any case, the issues are far from illuminated, and the greatest immediate impact of science on such systems, I submit, will be methods of studying and laying out clearly what the choices really are, what is known, and what is merely surmised about power resource alternatives. This is consistent with various other studies such as a recent 5-year one issued by the Twentieth Century Fund entitled "Civilian Nuclear Power: Economic Issues and Policy Formation," prepared by Philip Mullenbach, long associated with the AEC. He summarizes our efforts up to now as ones that "have progressed in eight years from excessive hopes to chastened resignation." It is seemly that this panel take heed to lessen the chance that such statements have later to be applied to great scientific movements now in full flight, such as our space endeavors.

MATERIALS AND NATIONAL SCIENTIFIC PROGRESS

Along with this great chance for a new era of wise planning, decision making, and systems analysis may also come a new level of achievement based on the science and technology of materials. Indeed, it was found at the beginning of the space epoch, in studies of major technical priorities which we made in Dr. Killian's office at the direction of President Eisenhower in 1957–58, that the limiting ingredients of urgent programs such as intercontinental ballistic missiles, space satellites, powerful boosters, and many other demanding elements for the national security were the materials available for realization of concepts and designs. Beginning in 1959, a National Materials Research Program was constructed to augment the notable progress that solid-state physics, chemistry, and metallurgy had established in the late 1940's (reflected in the discovery of the transistor, metal whisker tenacities, large-scale applications of polymer science, notable advances in ceramics, and the like). The present form of the national program involves about 14 major university centers for interdisciplinary study of materials. It has been almost entirely supported by the Advanced Research Projects Agency of the Department of Defense, with the special attention of Mr. Charles Yost. It does not yet, however, involve significant modes of transition of basic science into applied science and technology. Nevertheless, some important efforts are being planned for this.

This powerful and cumulative knowledge of the physical, mechanical, electrical, thermal, and chemical qualities of solid matter—whether it be solid propellant, rocket case, heat shield for ballistic missile warhead or manned satellite reentry, or the thousands of less sensational new materials developments—affects equally important advances in new materials for the fabric and operations of each of the complex systems industries we are discussing. As happened for the computer components and the industrial control mechanisms that were mentioned earlier, the application of new materials will also guide the growth of powerplants and distribution systems, of all kinds of materials of construction, and certainly of the public works involved in highway and airport transportation facilities. Simply to give a casual sampling of what forms this could take, a few areas of highest activity in materials development and processing will be cited.

PROCESSING OF EARTH SOLIDS

Hydrothermal synthesis of minerals might develop so that equivalents to mortars and concrete would be produced at construction sites by hydrothermal pressure vessels little more complex than present unwieldy (but mobile) cement mixers. Such a synthetic preparation of the previously elusive electrotechnical and structural material, quartz—composed of the two most abundant elements on earth, silicon and oxygen—is now a finished task with high production of superior units from the factory at Merrimack, Mass., and some other production centers, but the field is barely taking hold for other materials. It seems of high utility in view of recent successes with aluminum oxide systems and asbestos analogs; and even the familiar but excitingly versatile zinc oxide is suitable for controlled crystal growth from aqueous systems at high pressures and temperatures. It is too soon to expect that both roads and houses can be extruded from a hydrothermal process vessel using sand or cheap mineral components gathered from the site as the structural material. However, this is a clear goal provided by the pace of scientific discovery in this field. Common clay will not forever elude uncommon science.

Indeed, the modification of other forms of matter by means of intense pressures may follow the historic achievements of the General Electric laboratory in commercializing diamond synthesis, thus providing whole new ranges of materials properties. The late Professor Percy Bridgeman foresaw this in the transformations he achieved in his pioneering high-pressure studies. The recent work of Professor Willard Libby at the University of California at Los Angeles has strengthened our expectations of progress. The import of these studies is well shown by the current finding that indium antimonide, a semiconductor, can be converted with suitable pressure and temperature cycle to an electric superconductor below about 2° K.

ROLE OF COMPOSITE MATERIALS

We shall also expect new combinations and ways of using solids to have an increasing impact on the industries being discussed. Here one of the major influences of the new science of solids has been to reduce the compartmentation of technology which had characterized the materials suppliers—the metallurgical and chemical industries on the one hand, and the major materials users such as the construction, transportation, power, and communications industries on the other. Indeed, fragmentation within the materials industries themselves was such that combinations of metals and plastics, of ceramics and glasses, or of fibers and adhesives were dependent, at least until recently, on technical developments in consumers' laboratories. Obviously the requirements of space technology for the ultimate performance of mechanical, thermal, chemical, and electrical structures quickly dissolve traditional barriers to use of combinations of materials. This was found dramatically at the beginning of the ballistic missile development in 1954–55 when the concept of the ablative heat shield, based on fundamental studies of the thermochemistry of cross-linked polymers combined with inorganic fibers, soon displaced the traditional refractory metal heat shields and nose cones which had been assumed to be indispensable up to then.

One of the dramatic techniques of combining materials is through bonding layers of them, such as in organometallic laminates, fiber-reinforced plastics, honeycomb structures, and the like. Again the position of these light, strong, often expanded systems in space technology is familiar. Already they have a firm position in construction, power, and communication industries and they will probably be extended largely in the next few years to automotive, aircraft, and other transportation fields. The pertinent issue for this discussion is, however, that we are just learning the possibilities and basic qualities of adhesion. Examples are the current discoveries of Schonhorn and Sharpe on amphipathic monolayers whereby single (Langmuir) layers of suitably composed molecules, such as stearic acid, can produce bonds between polyethylene and aluminum of high strength and durability, so that a great range of new structures can be assembled. Other examples are the bonding fabrication of the lighter metals, such as the magnesium-aluminum solders discovered by Bouton a few years ago, the thermocompression bonds of Anderson, which with properly applied shear stresses are able to yield enduring bonds between metals such as silver, zinc, and tin alloys, and inorganic and semimetal substrates.

Composite processing, such as in the new low-temperature extrusion of pure metals like aluminum for sheathing over thermoplastic insulated cables, promises to have dramatic influence on the materials of the new urban growth. Above all, we can expect such classic operations as the nailing together of buildings to be modified progressively by use of quickly applied adhesives, foreshadowed notably by the epoxy polymers.

MATERIALS PROPERTIES AND CRYSTAL PHYSICS

Beyond the striking new range of materials properties that has already been implied lies a vast domain of basic physical and chemical effects whose industrial import is now barely visible. No doubt these, too, as broad manifestations of materials science, will be invigorated by the great expectations of our national space activity. Thus, a subject that we might call phonon circuitry or, more broadly, phonon engineering is arising from the deepening insight into the lattice vibrations of crystals which are responsible for crystal temperature and for their thermal and other transport properties. In the past few years, in studies connecting sound-wave transmission and absorption in solids with other qualities involving thermoelectric properties (themselves dependent on interaction of phonons or lattice vibration waves with charged particles in crystals), and through theoretical understanding, we have found that a certain control can already be devised for the transport of heat in matter.

Engineers have known for generations that heat transfer was one of their major limits in the design of effective power-generating, automotive, electronic, and even computing equipment. It is clearly a principal variable in effective space operations; for instance, the heat balance in the Telstar satellite was one of our most delicately managed qualities influencing the control, communications, solar-cell, and spin-stabilization designs. The time may be coming when we can select and specify optimized thermal qualities for all kinds of massive structures as well as the tiny ones which we now investigate and regulate.

REVOLUTIONARY ASPECTS OF MATERIALS SCIENCE

Could there be impending discoveries in science so profound that they would recast much of our expectations and our beliefs of what the industries covered in this part of our consideration can do in the near future? Indeed, there may be. Such results could ensue from systems of materials which possess no electrical resistance under the conditions of use. These are the so-called electrical superconductors known casually for five decades since the observations of the great Dutch physicist Kammerling Onnes, who found that at temperatures approaching absolute zero, such as those of liquid helium, many metallic elements and some alloys would exhibit superconductivity.

However, in the past decade, B. T. Matthias and his associates have revolutionized the resources in this field by the discovery of several hundred intermetallic compounds and solid solutions. Some of these, such as niobium-tin, exhibit much higher transition temperatures than ever before encountered in metallic systems (niobium-nitride being one of the earlier nonmetallic cases) and its transition to superconductivity at 18° K makes cryogenic systems easily manageable. New theoretical understanding, such as the Bardeen-Cooper-Schrieffer theory supplemented by various improvements, coupled with empirical rules of Matthias, have vastly extended opportunities in this subject. This is emphasized by the discovery in the past year by Geballe and Matthias of superconductivity in some new elements, including the common element molybdenum, where even 100 parts per million of magnetic impurities such as iron had previously obscured the desired effects.

Then the whole situation was dramatically opened up by the findings of Kunzler that many of Matthias' systems would remain superconducting in high magnetic fields. This situation was previously excluded by experience and expectations. A new realm of superconducting solenoid electromagnets has been achieved, and also the most promising approach to containment of plasmas and simplified techniques for the study of thermonuclear fusion as well as magnetohydrodynamic power facilities have been given a new thrust forward.

Magnetic fields approaching 90 kilogauss have been generated in hand-size equipment ("powered" by a flashlight battery). Although part of this is necessarily at low temperatures, part can be operated at ordinary temperatures. This may be an exciting foretaste of whole new generations of power control equipment, transformers, and perhaps, ultimately, transmission lines. These, along with suitable superconducting appliances, would truly refashion our concepts of urban development and the service industries fundamental to its progress.

PANEL DISCUSSION

Dr. Richard H. Brenneman: The objective of this conference is not unlike that spelled out in the Constitution of the United States as the objective of the patent law: "To promote the progress of science and the useful arts." Also, as a nation which has demonstrated the ascent to world power and an opulent commonwealth by virtue of its investment in applied science, we are justified in asking: What more will the science dollar buy us; are we investing it wisely; and what of urban life, our shared abode, during the race for space?

Our confidence in our own inventiveness, our machine-based technology, was inspired by the conversion of a wilderness into a science-fiction society in the span of a single century. Accounts of the track-laying gangs for the Union Pacific Railroad record that as late as 1869 the men were issued not only picks, but also rifles to fight off the savages. We may ask first, Is history relevant when it tells us about inventiveness developing into industry? Are the parameters that formerly were conducive to increased productivity still applicable? Also, do the criteria by which we have measured progress in the past continue to be applicable to the new dimensionality that our technological capacity and national objectives have assumed?

The continuum between search, discovery, and utilization is subject to many influences, and some of these that relate to the areas of interest of this seminar may be reviewed historically.

In communications, a useful example is telegraphy. Invented in 1837 by S. B. Morse, it served nearly every community by 1850, a delay of 13 years. Conditions that favored its growth must include a governmental offer of $30,000 for a workable system, the efforts of a promoter named O'Reilly who sold stock as fast as wire could be strung, the literacy tradition of free education, and the popularity of "news" papers. Added to these were the signaling needs of the railroads and the military along with the expectation and realization of private profit. So telegraphy fell on fertile soil.

The telephone, invented by Alexander Graham Bell in 1875, materialized into an operating company in 1879. Here was a delay of only 4 years. Much of the ready exploitation in this case was due to the experience Western Union had acquired with the telegraph.

An early example of another communications device, the typewriter, was constructed by William Bent in 1829. In 1867, a patent was issued to C. L. Sholes. First efforts to market the device were aimed at authors and ministers, and a boom did not develop until the early 1890's when the business-office market ripened. The delay of 20 years in this case can be attributed to unimaginative marketing.

In the year 1907, Lee De Forest patented the audion. However, the high-vacuum pump was still 3 years away, and the research urgency of World War I was 10 years away. But De Forest did broadcast an opera from Chicago in the year 1910. The public "discovered" the entertainment value of radio in the early 1920's. Amateurs with their passion for crystal sets preceded the mass market by 10 years. In 1922 there were 30 licensed broadcasting stations in the United States, 15 years after De Forest's patent.

Boris Rosing of Russia conceived of a television system using a cathode ray tube in the early 1900's. Thereafter, Philo Farnsworth, just turned 21, demonstrated television by means of an image dissector in the summer of 1928. He had read Rosing's published article. Meanwhile Vladimin Zworykin, a former assistant of Rosing's, developed the iconoscope. Cross-licensing agreements furthered the cause of commercial television, which blossomed after World War II. Uniquely, about $10 million were privately invested in the development of television before 1940. Within 10 years, television and radio accounted for a $2 billion industry, of which TV represented the larger portion. Here again was a typical 15- to 20-year delay from demonstration to industrial development and public acceptance.

In the more sophisticated area of specialized research equipment, the historians of technology tell us that 50 years is an average time lapse until such equipment is reduced to standard industrial practice.

What are the lessons that the above examples portray?

The first consideration is the search. Congressman Miller has said that $17.8 billion will be the annual expenditure in the United States on research and development. That sum seems sufficient for a great deal of looking about and testing; yet it is not so grand when viewed as a percentage of gross national product—approximately 3 percent. If, indeed, $10 million in development money, as in the case of television, can be pyramided into a $2 billion industry within a decade, then $17 billion is more than adequate.

But how is this money spent? For what are we searching? Defense and space projects account for nearly 80 percent of the R&D. Our dedication to national survival, coupled with prolonged frustration with arms-control agreements, hardly presages any significant reduction in defense R&D. As for the space race, this has so captured the public's fancy and spirit of adventure that it too will likely forge ahead. As a sublimation of nation-state aggressiveness and an effective international détente, the space race humanely incorporates its own justification.

We are left then with the alternative of (1) encouraging more R&D on consumer-product research, if new products are the answer we seek; (2) improving the cost effectiveness of the R&D effort already funded; (3) concentrating more effort on the translation of space and defense technologies into commercial industry; and (4) looking beyond new consumer products for economic stimulation.

To encourage more R&D in the consumer-product area, which Commerce Secretary Hodges describes as "badly wanting" at some $4 billion yearly, the Government can offer inducements in the way of tax advantages or low-cost-loan guarantees. But the scientific manpower problem represents the most severe obstacle. Qualified scientists are in short supply, and private civilian-type research is hard put to compete with the adventure of space research.

The problem of insufficient scientists introduces a larger and more persistent problem, yet one which seems more susceptible of solution. This problem is the cost effectiveness of research and development. Do we presently enjoy an optimum return for the research dollar spent and the research hour invested?

Improvement suggestions from persons engaged in research run the gamut from applying hard-nosed supervision of the investigators to introducing automation into the laboratory. The machine will not replace the researcher but will give him more time for investigative effort.

Also, the unique and independent professional status of the research scientist, hiring out to industry, has provided an insularity and deference from top management. There is almost an idol-worshipping appreciation of the R&D division as holding the corporate future in its hands; thus, this division is considered to be neither subject nor receptive to standard management controls. Combining novelty and rapid growth, industrial R&D activity has so far escaped thorough cost-effectiveness analysis. Rather, a broad general criterion is singularly applied, to wit: Does it pay? We have to look forward to greater administrative efficiency of R&D.

With regard to transference—making available to general industry those processes, techniques, and special products which have grown out of government-sponsored R&D—a program already launched for this purpose by NASA shows promise and is gaining momentum. It is likely to enjoy additional funding as its benefits become more demonstrable.

The subject of transference of aerospace findings draws attention to the larger problem of exchange of information generally. An investigator is wasting valuable time if he doesn't initiate his efforts in cognizance of all previously relevant research. A novel approach can be very promising, provided one is aware of the similar approaches which led into blind alleys. How can one be certain of the originality of his research? Scientific communications are now abysmal. According to a United Nations' summary, a communication concerning chemistry is presented once every minute somewhere in the world. Every 3 minutes there is a report on physics, and every 5 minutes a report on medicine, biology, and electronics. The UN counts 115,000 research laboratories. An estimated 50,000 medical journals publish 1,200,000 articles each year, while an equal number of technical journals publish 100,000 research reports.

Thus, information retrieval has itself become a major research need. We can look for greater R&D productivity when the harvesting, storage, and retrieval functions can be systematized into total information centers.

Continuing with the links between search, discovery, and utilization, let us examine the discovery phenomenon. Much of the R&D with which we are associated falls into the programed, Pert-charted category more familiarly known as the "brute force technique." The concepts are already crystalized and the investigation concentrates on finding a suitable mix, improving performance, miniaturizing, and increasing power or capacity. This description does not do justice to the splendor of R&D accomplishments, but the point to be made is that the conceptualization which leads to discovery is a creative rather than a disciplined manifestation of intelligence. In short, we must have qualified scientists to accomplish an investigation, but scientists have no monopoly on creativity. Thus, are we taking full advantage of creative resourcefulness from wherever it may reside in an organization? What efforts are made to uncover it? Suggestion boxes only serve to remind an organization of the crudity of its mechanisms to elicit intelligent participation. Brains are in no wise partial to the university graduate.

With regard to utilization, we are considering here a confounding problem. Public acceptance, the ultimate determiner of the degree of utilization, is based on a number of imponderables. Fortunes are made and lost in accordance with accurate anticipation of these factors. But even before the public acceptance can become manifest, or is given such chance, there are obstacles to be dealt with in a free society. The restraints applying to labor-saving devices are legion, while bureaucratic economic and cultural interests have also effected restraints on technology. Lobbying expenditures reflect the power of these interests; they are estimated as more than $1 billion yearly.

In a recent issue of a technical journal, the complaint was made that industry is not yet ready for the atom, that there exists a relatively untapped nuclear-energy market which can turn millions of already invested R&D into profit. The restraint in this case, the author asserts, is due to public fright about nuclear energy generally and to a lack of sufficient sophistication among technical managers to assess valid applications.

However, several pilot plants to utilize nuclear power have already been constructed and more will be built this year. This example illustrates another facet of this problem and one to which the scientific community, industry, and government should give attention. It can be represented by the term "full utilization." Too often a search for new products and processes takes precedence over expanded application of that which is already available. The retailers complain that since the 1940's nothing has been developed to match the marketing impact of TV. Yet color TV, educational TV, UHF, and closed-circuit special-use TV are still in their infancy.

Perhaps the printing press was the first instrumentation for mass production. Yet the newspaper market was long oversaturated before paper-backed book publishing began to be exploited. There is not yet available a paper-backed encyclopedia, though where is the moderate-income home without a need for one? Small refinements in processing and cost control can result in wider application.

In a very real sense, this conference is posing the question: In light of the tremendous expenditures on new technology, what is the relevance to our needs—the needs of industry and of the city? In short, what is going to happen to us?

The journal of the Patent Office Society specifies 78,710 patent applications in 1955; yet despite a doubling of the billions in R&D by 1960, patent applications climbed by only 621. Perhaps there is a time lag here which will result in a sharp increase in patent applications at a later date. On the other hand, these statistics offer some evidence that the space and defense industries are not the most promising source for generation of commercial products.

There is, however, ample cause to speculate optimistically on the long-range benefits and economic stimulation derivable from the research in support of weather and communications satellites, solar-energy conversion, nuclear-energy uses, thermionic conversion, biomedical instrumentation, new fabricating materials, high-reliability production, remote-guidance techniques, and managerial and decision-making controls.

But another issue arises here in response to the previously posed question, "What is going to happen to us? The implication becomes apparent by simply asking, What do we want to happen?

It is within our reach to emphasize the greater expressiveness of life. Perhaps that to which we refer as the alienation of the individual, the lethargic indifference to politics and the business of government, results from the frustrating sense of remoteness from the center and function of decision making. Yet to impose the technology of modern data processing on our voting technique—and this is possible with existing hardware—would permit balloting to become less of a ritual, and more frequent and functional. We would have immediate democracy.

Before taking advantage of the heroic opportunity of using international communications satellites as an instrumentation toward worldwide democracy, we need to exploit the new communications devices to close the gap (which might be surprisingly large) between the popular will and representative voting. A case in point is the issue raised by boxer Davey Moore's demise. The Governor of California could only promise that if legislative obstacles can be overcome, the citizenry might be given an opportunity to vote on the abolition of boxing sometime in 1964. Is such a delay commensurate with our advanced technology in communications?

I should like an opportunity to vote directly on this issue, and also on Federal aid to education, Medicare, civil-defense measures, and so forth. Where is the person who prefers to write a letter to his congressman or to a newspaper in lieu of a referendum? How are we to amalgamate the diverse economic interests of pressure groups more fairly than by increasing the effectiveness of democratic processes with up-dated communications technology?

The programing requirements to tabulate a national referendum on critical issues are readily manageable through use of the Sage system general-purpose computers and the telephone network existing today. The time delay would

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be governed only by the convenience of telephone location. We already have more telephones in the United States than voters. But the question is, "Do we want this much democracy?"

Research and development can take us down any road we wish to travel. If new products are deemed as the only economic salvation, this is the course to take. But our cities have been victimized as much as benefited by new product development or improved production techniques. In the large cities the automobile is considered to be out of control, as is the spreading blight of slum districts. Lewis Mumford contends that our cities lack the humanist dimension and are inclined to frustrate rather than nourish human relationships. New-product orientation will hardly solve this circumstance. It would seem that we have not thus far focused on man as the beneficiary, the central value determinant, of our science and technology. In our efforts to construct an enviable society, certainly the construction of our cities deserves a more dedicated and heroic effort than it has enjoyed.

Combining the resources represented by our idle industrial capacity and technological unemployment would put the rebuilding of our urban habitat well within our means. As a nation we have been splendidly responsive to tasks imposed from without, such as wars, the arms race, and even the space race; but we have yet to organize with equal splendor to accomplish tasks, such as a salutary urban environment, imposed from within.

Howard M. Gadberry: The following remarks will focus on the last few words in the title of this seminar, "What scientific developments will affect the transportation, communication, power resources, and construction industries *in the years immediately ahead?*"

We at Midwest Research Institute have been conducting for a year and a half, on behalf of the NASA Office of Applications, a pilot venture in seven midwestern states to see whether transfers can indeed be effected between the space effort and general industry. We have spent essentially 1 year accomplishing two things to our own satisfaction. The first was establishing that there are real, concrete, substantial technical developments of potential benefit to industry coming out of the space program; that we are assured of. The second was to gage the degree and nature of interest on the part of industry in availing itself of new technology. We have been gratified to find that there is a warm reception. We are now involved in the much more onerous task of bringing about these transfers expeditiously, and here we are confronted with the problem of trying to compress the time lag discussed by Dr. Brenneman.

In this context, some of the characteristics of the transportation, communications, construction, and power industries will be reviewed, and the technical developments that may be expected to influence these industries the most in the next 5 years will be indicated. In the ASTRA project the view is taken that unless practical applications of technology within a 5-year period can be foreseen, an action program is not yet warranted. Therefore, it is literally true that we are living on our intellectual capital. The technical developments that will have the greatest influence in the next 5 years are already with us in embryonic form.

Transportation and construction differ considerably from communications and power in terms of structure, cohesiveness, and organization. But all four of these industries have some important similarities. They are all essentially service industries; they all have a more or less intangible product; they are all more or less loosely connected to their customers; and, most important, the products that they offer are what the customer wants. Therefore, R&D efforts in these areas are usually directed toward improved economy of services—and, as we have heard, no single advance will change the whole structure markedly. Because these organizations are service organizations and are systems oriented, the greatest impact on them will be from the application of systems-engineering approaches.

Construction is already feeling some impact of systems engineering through the application of improved management techniques. The improvement—a slight improvement—in the management efficiency in the construction industry was readily evident. For example, about 24 percent of the applications of Pert and Pertcost to improve scheduling and improve reliability of meeting deadlines are now being made in the construction industry.

In addition to the expectations for the future—and this is difficult where the industries are loosely connected to their customers and the product is what the customer demands—the important feature is that there must be the determination to convert an expectation into a practical development. Therefore, the mode with which most of these transfers or impacts will be felt should be examined.

The impact of systems engineering has already been mentioned. Here you see a reflection back into the educational system, because systems engineering has grown largely out of military and space requirements. Many educational institutions do not recognize the fact that there is such a thing as a systems engineer, and they refuse to add systems engineering to their curriculum. Yet when the aerospace industries want to hire one, they run a full-page advertisement in a New York newspaper and they are besieged with inquiries because every systems engineers recognizes that they are talking about him.

The second impact is going to be in a revolution of the kinds of products offered by these service industries. Frequently the capabilities for achieving a desired result are already at hand and simply are awaiting the real demonstration of practical need and market. For example, men have been shaving for some years, and most of them have been wishing for a sharper, longer-lasting blade. We have heard for years about the possibility that the razor blade companies suppressed this innovation that would put them out of business. But just last year a British firm found out how to make long-lasting, sharp, stainless steel razor blades. Within 1 year two companies have put stainless steel razor blades on the American market. That capability of providing a needed improvement was already in their hands, or they could not have moved so quickly. It simply awaited the demonstration that the customer was ready for it, that the time for the idea had arrived, and that it was worth the effort of development.

Particularly in areas such as communications and power, there is going to be a new look at the products that are offered, largely in terms of repackaging and redesign and such things as increased unitization, portability, and prepackaged units. An interesting example is the innovation, just recently in California, of the unit-packaged freeway communications links. This typifies the kind of thing that will be seen in communications and power systems. Solar-powered rechargeable cells and digital communications pulse-code modulation were combined and the package was placed on poles every quarter of a mile down the freeway. By merely pushing a button, a motorist can call a policeman to come, and he in turn can send other messages from the box. This is the mode of transfer that we are likely to see—in terms of transportation as shown by the increasing systemization in the pipeline industry, which is beginning to pipe liquid coal into California from the coalfields in the Middle West; in improved utilization of power resources in portable packages; in job-site manufacturing and preconstruction at the job site; and in the development and application of fail-safe, error-free, jam-proof communications.

All of these things can be brought about as a direct transfer from some of the military and space systems now extant.

Dr. R. F. Muraca: Some of the ways in which current scientific developments will affect two of the industries under study in this seminar will be discussed here, and an attempt will be made to predict their impact on urban life.

For the most part, the communications industry is regarded as those industrial elements associated largely with the transfer of information by electronic devices from one point of our globe to another, or for that matter from one part of the universe to another, as is required by the space age. However, I like to expand the definition of the communications industry to include those aspects of communication relating to the transfer of information from person to person without the agency of electronic devices.

For example, our current educational system involves person-to-person visual and acoustic transfer of information from teacher to pupil.

Among the scientific developments which will affect this segment of the communications industry within the next decade is the availability of compact audiovisual systems based on closed-circuit TV. Increased use of television in the classrooms can be expected in the next decade; and this will reflect on planners for urban development, who will have to improve facilities within the school system for the generation and reproduction of educational television shows. In turn, the communications industry will profit, of course, by the sale of such items.

Another scientific development which may significantly change the overall structure of public school systems is the teaching machine. Current studies indicate that such machines show great promise for increasing the rapidity of learning of the average student and for making it possible for one teacher to instruct many more students than he now does. Some people anticipate that within the next decade every school system will have to provide for teaching machines as an integral part of the overall education program. If this comes to pass, it obviously will affect the composition and structure of the communication industry.

On the other hand, although studies of learning theory thus far have not greatly influenced the methods of teaching pupils in public schools, some recent advances in methods will enable teachers within the next decade to instruct a larger number of pupils and in this way minimize the need for teaching machines.

The communications industry as I have chosen to define it also includes all aspects of the printing industry. For the most part, this segment of the communications industry will be affected by the use of automation of production and product distribution along the lines already indicated by Dr. Baker. But new techniques made available by the impact of space technology may change the structure of the printing industry.

For example, it is technologically possible at this time to have a few centrally located news-gathering agencies communicate news items and reports by means of wire or microwave directly to automated typesetting equipment. With similar methods, it is possible to duplicate entire books and thus eliminate shipping costs. The impact of Xerography and other electrocopying methods in providing a multiplicity of duplicated material need hardly be mentioned.

Information-retrieval methods, largely carried out by the automated systems indicated by Dr. Baker, will probably not have as large an impact on urban life as they will in the fields of scientific endeavor and technology, and on the communications industry itself. Tremendous problems confront the scientific world in tabulating and retrieving scientific data.

Although it may not come to pass within the next decade, sufficient technology is available for the establishment of completely automated systems for maintaining city records, statistics, and entire plats of distribution systems and the like. It is to be anticipated that, within the next decade, groups interested in urban development will give serious consideration to the economic advantages of such information-retrieval systems, and thus the communications industry will be involved in providing services to cities and States as well as it now does to the Federal Government.

Current technology concerning the possibility of augmenting human intelligence is sadly incomplete, but it is interesting to conjecture the impact of a sudden jump of 10 to 20 units in the average intelligence quotient of the population. Perhaps the major result would be that the entire method of communication between politicians and constituents would have to be revised.

With respect to the construction industry, although hopes for exciting new materials for construction of houses, buildings, highways, and so forth, are high and are often held as enticing carrots for continued research projects, it appears that current scientific developments will have very little effect on today's construction practices. To be sure, we have available excellent adhesives, polymeric substances—foamed, cast, extruded, or laminated—aluminum, wood composites, enameled metals, and a host of other materials of this type which might be used for construction. The usefulness of many of these products has been brought out by the space age as we know it today. But there are two major barriers to the use of such materials. The first is their excessive initial cost in comparison with common materials of construction such as wood and stone; the second is a natural resistance to their use, either by consumers or, more importantly, by building codes. Nevertheless, increased use of these materials in building construction is expected over the next decade.

On the other hand, some interesting *techniques* for the construction of buildings, highways, and so forth have been developed to the point where they will undoubtedly find more use in the next decade. For example, substitution of prestressed concrete beams for steel has already made possible the construction of earthquake-resistant structures such as San Francisco's thousand-car Downtown Center Garage. It is anticipated that apartment-house construction of prestressed concrete will be commonplace in another ten years. Further, as interest in this technique is developed, various methods of designing prestressing machinery will be devised, and it will be possible to fabricate construction of a kind that we haven't seen thus far.

Within the next decade, we should also see increased use of fire-resistant materials (probably the same kind of materials that are used in rockets as we know them today) and of corrosion-resistant metals, plastic pipes for plumbing, and paints that are durable for at least 20 years. The last item alone should thrill urban planners and even the construction industry; for after all, what is dingier than an old building with no paint on it?

Returning to the matter of interesting construction techniques, it is important to point out that many of these techniques permit utilization of the products of modern technology, even though the cost at first sight appears to be inhibiting. This comes about because the techniques cleverly make use of minimum quantities of these materials. However, most building codes will not permit use of these techniques. Thus, what is required within the next decade is an extensive evaluation of both materials and construction techniques and a rapid modification of building codes to incorporate the results of these findings. In this way, the construction industry will be permitted to substitute less costly methods with benefit to both consumer and the industry. Only in this way can the tremendous variety of techniques developed by the space program for shaping materials, joining them, and finishing them be used by the construction industry.

Dr. Louis Winnick: One of the minor achievements of the space age is that the science-fiction writer has become its laureate. No longer is science fiction relegated to rather oversized magazines with lurid covers. Today every publisher, no matter how respectable, vies for the product of this small and special breed of scribbler who, 30 years ago, reckoned a trip to the moon to be no more marvelous than a summer excursion, and who could in a brisk paragraph or two solve the most fiendishly complicated technical problems.

A genuine talent among today's science-writers is Arthur C. Clarke. His most recent book, *Profiles of the Future*, would make a fitting textbook for this panel, for much of it is devoted to the relation between the newer technologies and the problem of urban transportation. With a practiced eye and the confidence of a veteran, Mr. Clarke takes a long look into the future, well beyond the frontiers of current research. He reports back a rather impressive array of new inventions. In the foreground is the ground-effects machine, a vehicle that propels itself about on a cushion of low-pressure air, moving with equal facility over land and water and making obsolete both the wheeled vehicle and the hard-surfaced highway. In the middle ground, Mr. Clarke can see moving belts and such things as antigravity. And in the distant background stands something called teleportation, a method of transporting matter by some form of communication technology. This last I cannot explain for the simple reason that it lies beyond my powers of scientific comprehension.

Mr. Clarke can, like Janus, look backward as well as forward. Looking backward, he finds that the most efficient form of personal transportation suitable to the modern city is the horse, a self-steering, self-reproducing vehicle that never goes out of style. For trips of up to 10 miles, Mr. Clarke would accord the horse as honorable a role in the transportation system of the near future as the ground-effects machine, which has its most useful application to trips of more than 100 miles. Now many will say that the prospect of millions of machines ejecting blasts of air over ground areas where millions of horses have just trod does not portend a very inviting future. At best, the blessings of these transportation technologies would be mixed.

But this is precisely the nature of the urban transportation problem: each technological innovation in transportation from the wheel to the automobile has proved to be a mixed blessing. This is so because transportation technology directly and intimately affects the shape and arrangement of urban areas. An improvement in air-pollution controls can be regarded as a total gain—every urban dweller will benefit—but this is not necessarily true of a new network of highways which brings new supplies of residential land into the market and siphons off from the city its middle-class white residents. Likewise, every urban dweller will be made better off by an improvement in the technology of fire control. Indeed, the importance of improvement in this field has been underestimated. It is difficult to imagine how the modern city could function were it still subject to the frequency and destructiveness of the urban fires of the 19th century. But such unqualified gains are not the case when a new subway line is built, for the result is a rearrangement of land use with benefits to some consumers and investors and severe losses to others.

This brings us back to Mr. Clarke's prevision of an antigravity force that would permit man and vehicles to be propelled in three dimensions at enormous rates of speed with negligible inputs of energy. In short, urban transportation would become very nearly costless and very nearly timeless. Such an innovation would have at least two major consequences. First, it would confer upon mankind an enormous gain in economic welfare, for much, if not most, of the real cost of producing America's gross national product represents the cost of traversing distance—the cost of moving goods and people from one establishment to another, and, within each establishment, from one function to another function and from one machine to another machine. The second consequence would be the end of the city as we know it, for the city has its economic origins in the friction of distance. Because of gravity, distance imposes a huge cost in energy in order to move goods and people. This cost is only partly reflected in the value of our vehicles, highways, and roads; in the consumption of fuel; and in the wage bill of all employees associated with transportation and goods-handling. There are secondary burdens. Distance also imposes uncertainty costs and time costs, though the billions of man-hours lost in the journey to work each year are not usually computed in our economic accounts.

The city represents man's response to the costs and time of travel, for the city permits proximity—the closest possible arrangement of establishment to establishment and of the labor force to establishment. The city reduces uncertainties by providing a fuller flow of information, the easiest possible face-to-face contacts, and the widest variety of choices of jobs and employers, of salesmen and customers, of services and goods.

Major and even minor improvements in transportation technology lessen our dependence on the principle of proximity and therefore make the city increasingly dispensable.

Will the exciting prospects for transportation technology be all to the good? Will the ground-effects machines, the electronically guided highway, the vertical take-off plane, the turbine engine, the Levacar, and moving roadways add to our wealth and convenience on the one hand but, on the other, rob us of some cherished heritage?—for we have not yet been able to define what we mean by the good urban life. Nor will we soon find a calculus by which the costs and benefits of change can be balanced against each other, particularly when the benefits accrue to one group and the costs are borne by another.

It must be remembered that technological innovations are guided by engineering principles of efficiency and ultimately by economic principles of least cost. However, efficiency and least cost are not dependable guides to optimal choices; they represent only part of an equation, the other half of which—depending upon context—contains such terms as revenue, utility and satisfaction. Urban man has not always, perhaps not even usually, opted for least-cost solutions. Obviously the price of automobiles would be greatly lowered if only a single model and a single color were produced. But the consumer has ruled otherwise. His preference is for cars in a hundred models and a hundred colors. The number seems to be increasing, and this fragmentation of choice has added substantially to the manufacturing, distributing, and selling costs of the automobile. Likewise the urban consumer has shown a decided preference for relatively high-cost private transportation rather than low-cost public systems. Transportation schemes which are based on engineering principles of efficiency and which do not take adequate account of market choices may go astray.

To summarize this far from original warning: improvements in transportation technology tend to decrease the frictions of distance. Every increase in vehicular velocity extends the range of locational choice. As the network of metropolitan transportation routes grows ever more complete, there is a corresponding increase in the number of places that become competitive with the city as a location for employment and residence. The metropolitan area becomes more extended, with sprawl outside and gray areas inside. Perhaps, someone will say, we ought to be willing to go back to the horse and thus preserve what is left of the city instead of watching what seems to be its slow demise through technological change. This is a dilemma of the space age.

Dr. Charles J. Zwick: Two brief comments will be made here with regard to the papers so far. The first comment is one of general agreement with Dr. Baker. I think the important impacts of new science and technology will be on processes and product improvement, better products more efficiently produced—not necessarily radically new products. There is an emotional appeal in the radically new products. If we look around, we can see a number of examples of product improvement and more efficient processes which tend to bear out Dr. Baker's thesis.

The second point pertains to the indirect impact on the national economy that will come from expenditures on R&D approaching $20 billion annually. This impact, as it affects income and employment, will in turn affect the demand for transportation, power, and construction.

An example can be seen in Denver, Colo., which has felt the impact of the defense industries. Houston, Tex., also is witnessing a slight change in employment patterns. This total change in regional distribution of employment and increase in wealth in our society is affecting the demand for transportation services, power, and construction. To quote some statistics: In the early thirties, the consumers spent about 9 percent of their budget on transportation; in the late fifties, roughly 12 percent of their budget was spent on transportation, and this was with a budget that was roughly twice what it was in the early thirties. Or, stating it another way, during this period income essentially doubled and expenditures on transportation tripled. Transportation industries had high income elasticity. Therefore, a study of the indirect effect of science and technology on employment and distribution may reveal a more important impact on these industries than a look at the direct effect.

Certainly the whole aspect of our metropolitan areas is changing as a result of a complex of forces. This complex is leading to problems with public transportation that Dr. Winnick mentioned.

To the extent that defense and space activities, with their great emphasis on research and development, are driving and shaping our economy in terms of employment patterns and types of industries, science and technology are having a major indirect effect on our society. The challenge appears to be: Can we use the R&D activities directly to alleviate the problems they are inducing, or, more positively, exploit the opportunities for improvement that they afford?

GENERAL DISCUSSION

Robert H. Ryan: Dr. Baker indicated a certain amount of impatience with respect to transfer of information in the decision-making processes. He mentioned DOD and AEC, and the fact that there had been a delay of a year in agreeing upon something that, presumably, could have been agreed upon in a much shorter time. Would he expand on that, please? Is he suggesting a new mechanism?

Dr. Baker: I am suggesting that more expert and voluminous techniques be used to handle larger volumes of information. The use of systems analysis to focus on the essential technical problems involved in a nuclear-powered aircraft, for example, could have resulted in very much faster action.

Dr. Sherman J. Maisel: Is the implied assumption, then, that we are misdirecting the amount of money we are spending on research—that if we put even a small fraction of this into systems analysis, we would get much more usefulness out of the work we are doing than we are getting out of the present system?

Dr. Baker: I think I would probably be reflecting the sentiments of the panelists with a resounding "Yes."

Dr. J. Herbert Hollomon: I would like to ask two questions of the transportation experts. Do they see serious crises in mass transportation or urban transportation? If so—or if not—what do they view as the major changes in the means of personal transportation in the next decade?

Dr. Winnick: I suppose when anybody has trouble getting home from work, it becomes somewhat of a personal tragedy; but it is hard to imagine crises in the usual social sense of mass hardship over a rather brief time period. It is hard to find convincing evidence that we face such a prospect at the moment. When a heavy snowstorm blocks some major commuter roads in the New York area, where dependence upon commuter roads is quite heavy, the city goes on functioning reasonably well—perhaps to everybody's astonishment. It is a little hard to define "crisis."

Your second question, about personal transportation, I would refer to people better qualified than myself. My own instincts tell me that probably we are going to get a lot more of the same, probably a little better designed cars and better designed roads, rather than a major innovation that would revolutionize traffic modes.

Dr. Muraca: I would basically agree with what Dr. Winnick has said. If performance is measured in terms of elapsed time, certain things in most major cities in the United States are getting better, not worse. So there is no crisis in this sense. There is one, I think, in the sense that the public transportation systems that now exist are in trouble, and there is a need for some sort of public transportation system.

Cities are changing; they are undergoing major redistribution of employment patterns and residential locations. One group that is unhappy with this redistribution of activities feels that most of the blame can be put on the transportation system and therefore has an incentive for improving the transportation system. But as they improve the transportation system, they are probably hurting the urban form they want, rather than helping it.

If travel were instantaneous and costless, other factors, including personal ones, would have more influence on the locations of employment and residence. As transportation is made more and more efficient, employment and residence will be driven in opposite directions. The crisis is more concerned with this question of urban form than with urban transportation.

Dr. Hollomon: Then I deduce that neither of you think that, in the transportation business, there will be any substantial effect on its character, form, or nature resulting from military or space R&D.

Dr. Zwick: Yes, substantially, there should be. Things are getting better. George Hoffman in his study of the automobile predicted a 20-percent increase in efficiency over the next decade.

Sumner Myers: I think part of the problem here is an inability to define the transportation problem. When Dr. Winnick was asked what he meant by crisis, the parameters were not laid out. Nobody has referred to "user satisfaction" as a measure for optimizing. It has only been equated to speed. But there are studies which indicate that congestion actually produces a measurable user dissatisfaction. We know that congestion can be eliminated by some of the systems and techniques that have been developed. There are ways of solving *that* kind of transportation problem without necessarily blowing the city apart.

John Brahtz: I am particularly thinking of the heavy construction industry, the one that is in the hands of the professional engineers. Much of the material that was mentioned by Dr. Muraca has been available for some time. Why is it not being transferred into heavy construction? Is there something, for instance, that the professional engineering group should do?

Dr. Muraca: One of the biggest problems, of course, is in utilizing the material in its most economic form. As I pointed out, in general a bridge is built in a certain way. It must have a strength factor, a safety factor of so much. Those rules may have to be changed in the future to allow utilization of other materials. For example, the process of spinning rocket cases out of a glass fiber and epoxy might be extended to the building of bridge cables, but I wonder if our bridge-building code would permit it? We have to change our complete concept. Although these materials are available, they can't be used unless the old rules are reconsidered.

Mr. Brahtz: I realize that, and I was wonder- if there is something the professional engineering groups should do to orient themselves to these developments in technology so that they will be more receptive to them and incorporate these new developments into their products.

Dr. Muraca: I think that is the major problem. It is almost the same problem as the technological transfer of information. When you were a student in college, all the information was in the book and you still could not solve the problem. Now what do you do? I do not really know the answer; the problem implies a transfer of what an engineer knows to a building inspector or city fathers.

Mr. Brahtz: Would you agree, though, that the responsibility for this transfer lies with the professional engineer?

Dr. Muraca: Indeed it does, as a matter of education from the technical plane to the nontechnical plane.

Mr. Morrish: Anybody who has tried to change building codes in a small way knows the problem.

Congressman Jeffery Cohelan: I was intrigued by Dr. Baker's reference to the ANP program which has been abandoned after expenditure of some billion dollars of research money. This is a military research and development program, and I am wondering if what he is suggesting is: With the proper application of these techniques, would we have abandoned the program sooner?

Dr. Baker: Yes, preferably before it was begun. Of course, the elementary demands for simulation—for scaling of new and elaborate systems like that—were never accomplished. Schemes for these are available now, and they certainly must be applied in the future. The commitment to the impossible, if the laws of nature or our knowledge of them decree that it is impossible, is a heroic quality of our society but not a particularly productive one.

Dr. Harmer E. Davis: We have heard in recent years that the transportation problem may be ameliorated somewhat by the substitution of communications for physical transportation. I wonder if the communications and transportation experts would briefly discuss this.

Dr. Winnick: In some of the large cities in the country, some of the major remaining sources of economic strength in manufacturing are in the communications industry. That is, New York and Chicago have sizable newspaper publishing and magazine publishing activities. These are bound to the city for a good many reasons. However, utilization of some of the technological innovations in communications which would make facsimile production on automatic typesetting machines quite possible could strike another economic blow at the large city as we know it.

In many ways communication and transportation are the same thing. They both involve transference over space of something—of some information between two people or two establishments. Improvements in communication would have almost the same force as improvements in transportation, although the changes might be differently distributed.

Telephone improvements and the jet airplane have made it possible for headquarters of manufacturing corporations to pick and choose their cities more freely than they had before. As a result, the large office-building construction in the postwar era has been far more selective than in previous decades of urban history. Almost any city of any size in this country has in its center an office building plant as an inventory of office space. The cornerstone, or just the architectural style, of most of these buildings indicates that they were built in the first decade of the 20th century or, in some cases, in the early twenties. Since 1945, substantial amounts of office construction have taken place in only a few cities.

It seems to me that communications would have, in the long run, the same tendencies as transportation changes to reduce the needs for clusters and aggregations of establishments.

SEMINAR B

Can New Space and Scientific Technology Be Applied to Basic Community Problems of Water Supply, Air Pollution, Public Health and Safety, and Sanitation?

Chairman: STANLEY E. MCCAFFREY, President,
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PRESENTATION BY

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CAN NEW SPACE AND SCIENTIFIC TECHNOLOGY BE APPLIED TO BASIC COMMUNITY PROBLEMS OF WATER SUPPLY, AIR POLLUTION, PUBLIC HEALTH AND SAFETY, AND SANITATION?

Dr. Karl W. Wolf

To unfold the scope of the areas to be covered, one can cite a whole gamut of urban operations. Examples include sewage and refuse disposal, insect and rodent control, institutional and industrial hygiene, the sanitation of public conveyances, noise control, and so forth. It is obvious that to cover the topic in a meaningful manner, one must make a selection.

We have decided to concentrate for this presentation upon the areas of water supply, waste disposal, and air pollution. Not only do these areas constitute by far the most sizable operations within a community, they also present the major problems for future developments. Furthermore, in a very basic way they affect most of the subjects that will not be covered. For example, water treatment and sanitary waste disposal are major weapons in combating communicable diseases. Despite selective emphasis, however, this presentation still can only be suggestive rather than definitive. Many of the ideas presented in this talk have been collected in the form of notes over long periods of time. Because of severe time restrictions, it was not possible to trace and identify the respective authors.

DESCRIPTION OF THE AREAS OF WATER SUPPLY, WASTE DISPOSAL, AND AIR POLLUTION

We begin with a brief survey of the characteristics of these areas. While transportation and communications could be classified as the muscle of an area, water and waste disposal may be referred to as the stomach and the digestive system. To conclude this picture of human analogy, air would be associated with the lungs. As in the human body, as long as these organs work well, their existence is rarely noticed. When, however, one of them malfunctions, the whole system is affected; it may be even in danger of breaking down completely.

Water Supply

Water is vital to the life of people as well as industry. In 1960, at a population of 180 million people, the total U.S. water consumption, including industry and agriculture, was estimated at 325 billion gallons per day. By 1975 the population is expected to rise to 230 million people and the water consumption to about 450 billion gallons a day. This brings us within 10 percent of using up all the normal water supply available. By 1980–85 water demands are forecast to exceed natural water supplies. By then we must reuse water or convert water from the oceans on a large scale. This is the national picture.

Water needs vary widely on a geographic basis. A recent survey gives figures for various American cities ranging from 35 to 528 gallons average daily consumption per capita. The national average is forecast to reach 170 gallons per capita per day in 1975.

The investment in water facilities is sizable. The average capital investment is estimated at about $125 per capita for recent systems, with distribution facilities accounting for about 60 percent of the total investment. For example, cities with a population of more than 500,000 average about 1.5 miles of water distribution mains per 1,000 persons; cities with a population of less than 10,000 people average about 5 miles.

Current water treatment methods can be categorized into three major groups:

(1) Clarification by screens, sedimentation, and/or coagulation,

(2) Filtration mainly by sand and gravel and/or pressure filters,

(3) Disinfecting methods by chlorination or ultraviolet radiation.

Waste Disposal

Waste disposal covers two distinctly different kinds of operations: sewage disposal and refuse disposal.

Sewage disposal.—Sewage refers to waste waters from occupied areas. Even when highly concentrated, sewage contains less than 1 percent of solid matter. Three kinds of sewage generally are found in a community: sanitary or domestic sewage, liquid industrial wastes, and storm sewage. Liquid industrial wastes make up 50 percent of the total sewage in some communities.

Sewage generation is closely related to water consumption since 60 to 80 percent of the industrial and 85 to 95 percent of the domestic water consumed becomes sewage. Thus, with increasing population, the sewage disposal job gains in magnitude; and according to the U.S. Public Health Service, nearly half of the existing community sewer facilities are inadequate or outdated.

Sewage disposal costs are roughly equal to those concerning water supply. However, within the system, sewage treatment accounts for a larger share of the total costs than does water treatment.

While municipal sewage treatment is making great strides, nonetheless 25 percent of the liquid wastes are still dumped as raw sewage into the Nation's waterways and another 31 percent are given only primary treatment. At present, sewage disposal methods consist mainly of:

(1) Dilution and sometimes irrigation,

(2) Screening and sedimentation methods,

(3) Activated sludge and related processes,

(4) Sewage disinfection by chlorination.

Refuse disposal.—Refuse concerns the solid wastes that result from the processes of urban life. Refuse comprises a number of solid waste categories, the most important of which are garbage and rubbish. Garbage refers to food wastes while rubbish covers combustible items, such as paper or wood, and noncombustible items including metal cans and glass.

The quantity of municipal refuse collected varies widely, ranging from 1.4 pounds per capita per day in the summer to 5.1 pounds in the winter. The yearly average for all refuse combined is given at about 2.2 pounds per capita per day of which about 55 percent is estimated to be garbage and combustible rubbish. With increasing wealth, the amounts of solid wastes that will be accumulated will be monstrous.

The cost of collection of solid waste is an extremely large share of total costs. The average annual per capita cost of refuse collection amounts to more than $4.00. The average for the actual disposal is only about $1.00 or 20 percent of the total. Various methods are used to dispose of the refuse produced. Many of these methods are rather archaic but inexpensive. They include open dumps, sanitary landfills, incineration, hog feeding, composting, and grinding with subsequent disposal through the sewerage system. It is estimated that by 1965–70, about 50 percent of the garbage will be disposed of by grinding.

Air Pollution

Air pollution is the contamination of the atmosphere by smoke, dust, gases, vapors, fumes, and mists. The average person daily eats about 2¾ pounds of food, drinks 4½ pounds of water, and breathes 20 pounds of air. He can postpone eating and drinking, but he cannot postpone breathing.

Air pollution is called the "sin of emission." It affects almost everything in our environment—from clothing, skin, and lungs to metals and paints. The price of air pollution is exorbitant. At present, total cost in the United States is estimated between $7 and $9 billion; in 1949 total damage might have been around $2 to $3 billion. Air pollution thus far appears to be one of the scourges of civilization.

The automobile is said to contribute about 25 to 40 percent of all contaminants, the remainder coming in the form of soot, gases, and ashes from industry and to a large extent from the activities of the general population. Normally, the air acts like a giant sewer. Today two choices are given: one, not to overload this sewer; and the other, to increase its efficiency.

ANALYSIS OF RELEVANT SCIENCE AND TECHNOLOGY

Many people agree that science and technology are the most effective instruments for the creation of wealth and power in the modern world. What then is science today?

Today, science is widespread, is a large scale operation, and is systematically used and applied. Scientific activity is broken down into basic research, applied research, and development. Basic research produces the knowledge of why and how; it is explanatory and descriptive. Applied research investigates and demonstrates feasibility; it answers the question of how knowledge can be used for given purposes. Development executes feasibility on a scale outside the laboratory; it reduces the findings of the laboratory to practice. The result of development is technology; the result of basic and applied research is knowledge.

In order then to analyze science and technology with respect to water supply, waste disposal, and air pollution, we must look at these three categories of science. Time did not permit a comprehensive "fishing tour" through the vast ocean of science. Furthermore, only few of the items can be given briefly at random. A strictly scientific discussion will not be attempted.

Basic Research

The areas of basic research appear to present a rich hunting ground indeed, especially in the fields of research into the structure and transformation of matter and of life.

Life sciences research.—The discussion of areas in basic life sciences research in this presentation deals with cells, viruses, bacteria, and enzymes.

CELL RESEARCH is an excellent example of basic research; for there is one universal principle of development in the elementary parts of organisms, however different they may be, and that principle is the formation of cells. Cells, themselves, are organisms. Animals as well as plants are aggregates of these organisms arranged in accordance with definite laws. Many of the pollutants and elements of water, waste, and air belong to this group of matter—so also do many of the potential remedies. If large numbers of small molecules could not link together to form big ones, life as we know it would not exist. Processes of this kind go on continuously in living cells and we depend upon them for many materials of natural origin: food, wool, cotton, cellulose, and so forth. We depend upon these processes also for changes in and the destruction of many natural materials. Despite heterogeneity in the starting materials, however, the materials made by cells follow set patterns very closely. The process control effected by cells has been more exact than can be achieved at the present time in the laboratory—for example, in polymer chemistry. Thus, if we could employ the processes of living cells, a great advance would have been made. Cells are formed by division of preexisting mother cells. The death of the individual cell does not involve a break in the continuity of life. If the processes of cell generation, heredity, and mutation were better understood, new approaches might be developed for a self-sustaining process of removal or utilization of waste materials in water or air.

VIRUSES are smaller than normal cells and are parasitic upon them. They experience two stages of life, an extracellular or dormant stage and an intracellular or reproductive stage. Outside the host cell, the virus has no measurable metabolism and is apparently inanimate. When in contact with a suitable host cell, the virus becomes attached to the cell surface, disappears inside, and reappears some time later after having multiplied manyfold. In doing so, it frequently kills the host cell. A virus does not seem to have energy of its own; it must attach itself to a suitable host and use his energy to function. An essential feature of a virus infection is the entry of the genetic material of the virus into the cell and the direction of the metabolic machinery of the cell to make virus constituents. The virus supplants the genetic control of the cell's biosynthetic machinery and robs it of its normal source of information. It is an almost perfect transformation of organic matter and is self-perpetuating. The question arises whether harmless viruses exist or can be bred which would eliminate unwanted cells or cell residues from our environments by simply mutiplying themselves.

BACTERIA perform a similar operation. They also are examples of unicellular organisms. When they successfully invade a cell, however, they merely rob it of its raw materials and use the cell as an enriched medium for growth. At the present time, several oil companies are already investigating and breeding bacteria which feed selectively upon certain elements in low-grade petroleum, thereby refining it. In addition, these bacteria are also excellent protein cencentrates, comparable in nutrient value to fish and soya cake. These bacteria not only perform a very valuable service, they may even be used afterward with significant commercial benefits. Finally, research on bacteria cell walls presents another area from which we may derive benefits for managing our urban affairs. Cell walls prevent unwanted compounds from entering; yet on the other hand, nutrients and waste products must penetrate if the organism is to survive.

ENZYMES act as catalysts for most of the organism's metabolic reactions. They are one of the basic classes of chemicals in the body. Enzymes thus far are known to serve only one function: they speed up the chemical reactions tremendously. A reaction that might ordinarily take hours to occur, or that might not occur at all, can happen in a split second in the presence of an enzyme. Mastery over the enzymes may lead to fast, continuous processes for water purification as well as waste disposal.

Matter related research.—Matter related research in the past has been largely focused upon the production of nuclear energy and on the structure and use of radioactive isotopes. A third area concerns radiation, and it is coming up fast. Radiation to promote useful changes in materials may eventually turn out to have the greatest impact on our lives. In air pollution, for example, it could lead to the development of active converters versus the plain contaminant removal process frequently used now. Transformation of matter by radiation thus may turn a plague into a blessing by controlling the climate of our immediate environment for health or pleasure purposes.

Compared with chemical treatments, radiation has the following advantages: (1) temperature is no longer an important factor; (2) the reaction is readily controlled by the intensity of the radiation and the time of exposure; (3) radiation can be carried out in closed vessels and pipes; (4) no chemically reactive species need be incorporated; (5) it can carry out reactions in solid state; and (6) the final product is much purer.

Radiation already is used extensively for sterilization purposes. Sterilizing soils by chemical means, prior to planting, costs about $300 to $500 per acre. A portable nuclear reactor can do the same job more effectively for about $70 per acre. In addition radiation machines that work as an electron accelerator are already used for sterilizing drugs and cosmetics and for preserving and processing food. Such a machine costs about $60,000 at the present time.

Basic research in geology and in light.—Other areas of interest in basic research concern geology, geochemistry, and geophysics. Questions such as these arise: Can underground nuclear blasts be used to improve underground water collection and storage? Can they be used in waste disposal? Can they aid in the generation and utilization of sewage gas?

Within 25 to 30 miles of the earth's surface, the temperature is hot enough to melt rock. Deep mines—and the deepest ones are not even 2 miles below the surface—cannot be worked without special apparatus to dissipate the unbearable heat. Geysers are produced when cool water from the surface of the earth filters down to the hot rocks below where it is converted to steam. Geological mechanisms such as these perhaps may be used to convert sea water into potable water or to transform waste. Knowledge about geological mechanisms and about water and waste conversion will help to give an answer.

Finally, lasers with their capability for modifying light might provide another versatile instrument for solving our problems. Many of the dangers of air pollution, for example, are created by photosynthesis, by chemical reactions through light. The thought comes to mind whether the intense light energy of lasers could be used to effect additional—in this case beneficial—photosynthetic processes. Currently, fluid lasers are under development which promise to supply tunable laserlight, thus providing a selection among a variety of light wavelengths.

This concludes my highlighting of some basic research areas with respect to urban problems in water supply, waste disposal, and air pollution. Only a few areas were covered—and these, briefly. The discussion thus far has not produced a definite answer to whether science can be applied to urban problems. Dealing in the realm of basic research, nothing more can be expected. However, I think one thing has become clear—that the current work on the frontiers of scientific knowledge does offer a fertile field for identifying application opportunities with respect to solving problems in water supply, waste disposal, and air pollution.

Applied Research and Development

Applied research and development are treated together since frequently both go on simultaneously for a given field. Developments in one section may lead to applied research in another; and applied research is always conducted with specific developments in mind.

Cryogenics.—This term refers to the physics of extremely low temperatures. The question arises whether cryogenic or similar processes can be used in the separation of solid wastes. It has been found that materials become brittle at different degrees of low temperature. Being brittle they fracture easily and can be pulverized. The application of succeeding low-temperature gradients thus may aid in separating metals and glass from organic and similar materials.

Plasma physics.—Plasma-arc steelmaking uses argon gas heated to plasma temperatures. As the plasma expands, it emerges from a nozzle in the furnace as a high temperature jet with temperatures up to 60,000° F. The price of a 1-ton unit is about $100,000 at the present time. The question: Could plasma-arc techniques be used to convert sea water and sewage into potable water and perhaps even furnish simultaneously steam for electricity and other purposes? High-temperature chemistry made possible by the availability of various kinds of plasma jets and the high temperatures may lead to even more enticing methods of matter conversion with which we are primarily concerned here.

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Chemonuclear reactor for air pollution control.—A new type of chemonuclear reactor currently is under design. The reactor will be a vessel containing extremely thin corrugated fuel elements that give off radiation to interact with certain chemicals passed through the vessel. The initial goal is to develop a reactor that will convert atmospheric nitrogen to fixed nitrogen for use in making nitrate fertilizers and nitric acid. Ultimately it may be feasible to produce oxygen from carbon dioxide in reactors small enough for space voyages.

Foam fractionation.—Laboratory studies have shown that foaming removes not only the detergents from the waste water, but also substantial amounts of solids and organic wastes. This method, which favors continuous processes, lends itself best to the separation of complex and chemically unstable substances. It is especially useful when the concentration of the solute is low. Foam fractionation has already been used for decontaminating radioactive waste. Application of the foaming principle could help to solve the detergent problem. Causing the detergent molecules to continue foaming with the help of just plain air bubbles results in collecting not only about 95 percent of the detergents but also of other contaminants that may be in the sewage. Experts say that the bubbles soon collapse after being drawn away and that the remaining liquid is easily treated and can even be dumped into any river without causing obnoxious foams.

Ultrasonic devices.—The ultrasonic device is another category of a promising approach to water, waste, and air pollution problems. Ultrasonic waves can destroy materials as well as coagulate them. In air pollution, they have been proven to remove many of the solids that normally are blown out of smoke stacks. They also can solve foam problems in most situations where chemical defoaming agents are too costly. Typical operating costs for some of the newer devices are about 2 cents an hour when air is used as the driving medium. In one example, approximately 60 cubic feet per minute of foam has been collapsed per transducer, each being operated on 10 cubic feet per minute of air. In this application, the electrical energy required for supplying the air costs about 1 cent per hour.

Vinyl honeycomb cubes.—Vinyl honeycomb cubes have been suggested to replace heavy layers of sand and rock in a new technique for the removal of dangerous industrial wastes from water. The units are light enough to be stacked vertically and their great surface area allows rapid growth of the bacteria that destroy waste materials.

Many more examples of applied research and development products can be named. They include miniature type engineering, cold cathode electron guns, bridging agents for settling fine suspensions fast, and the use of extremely large nuclear reactors. It has been calculated, for example, that the use of very large nuclear reactors for sea water distillation could turn out 1 billion gallons of fresh water a day at 10 cents per 1,000 gallons. Again, the examples presented give but a skimpy cross section of the many technological possibilities that might be used for making our cities more habitable. It appears that we have the capacity to construct urban environments at will.

CONCLUSIONS AND RECOMMENDATIONS

It is obvious that the conclusion of this brief analysis is that space and new scientific technology *can* be applied to the problems of water supply, waste disposal, and air pollution. Consequently, the recommendation is to investigate science and technology further, to use it, and to do both with great determination. The question is how.

In starting, two ways may be suggested—the first concerning cost reductions for present systems and the other dealing with breakthrough type investigations. For both approaches, one naturally would suggest the application of system methods to obtain well integrated results.

But the key question remains: What is the system supposed to do? In other words, how do we want to live, and, even, what really do we individually want to become and what kind of environment or city is necessary to our growth?

In contrast to their utilization in the space program and in defense, science and technology must be seen within the framework of socioeconomic systems in the metropolitan sphere. Science and technology here are genuinely enabling factors, which, when properly planned, can lead to a maximum freedom of choice. Considering interdisciplinary approaches as well as the impact of science and technology across all kinds of metropolitan areas and functions, it becomes clear that partial, halfhearted planning cannot encompass the range of choices which our technology and wealth theoretically can make possible.

This realization that our problems can only be solved on a revolutionarily large scale means that a whole range of values now becomes a matter of social policy. Comprehensive planning will be necessary in a different sense of the word than it is used today. Key elements in this new type of planning require the contributions of the philosopher, the statesman, the visionary, the scientist, and the artist who is capable of transforming the concepts and goals into the physical shape of urban architecture. Such planning might demand technical, economic, and administrative means not yet in existence.

Comprehensive planning, furthermore, must incorporate to some degree a revival of Utopian thinking as an intellectual challenge in order to identify the numerous possibilities of metropolitan life. First, in the two-phase new planning approach, the planning team must deliberately divorce itself from narrowly practical considerations. It must forget about pragmatics and address itself to the potentials of the urban environment, since the ideas of the future influence to a great extent what the future will be. Creative foresight and planning go beyond experience. Together, they not only copy the past; they also combine past elements in new ways to construct better fitting results and they also introduce a host of new factors.

Planning is characterized alone by its forward look. It is, however, much more than prediction—it means shaping the future as one wants it to be and is capable of making it.

This, then, leads us to the incorporation of "the existing" or, in other words, the experiences, and to the second phase of the new planning approach. Here the dream or the idea is transformed to the attainable. Here, the more powerful the organization that implements and the more comprehensive the plan, the greater the chances of success because the more factors can be kept under control.

We do not leave, for example, the matter of defense or space research solely to private industry or to groups and associations dealing with foreign affairs. It is done in a tremendous cooperative effort in which professional military men and government scientists lead in the projection of systems requirements, the subsequent identification of inventions, and the consequently needed research. An interdisciplinary group of men must first identify the fundamental questions to be answered before genuinely "practical" or completely fitting solutions are possible.

The same should be done for solving metropolitan problems, especially in the utilization of science and technology. Both are ambiguous and can be made to serve a variety of often noncompatible needs.

Recommendations follow easily on the basis of the foregoing discourse.

(1) *Basic research concerning metropolitan life and metropolitan policies.* Conduct a comprehensive socioeconomic system analysis of the metropolitan area as a matter of basic research in order to establish a metropolitan theory in which the very why's and how's of metropolitan life are identified, measured, and integrated.

This analysis should not only synthesize the findings of many of the urban and metropolitan studies already conducted but also incorporate methodologies and findings from relevant other disciplines. For example, it must concern itself with identifying optimums in the geographical distribution of socioeconomic activity on a nationwide or even worldwide basis.

As a result, parameters for forecasting and "gaming" metropolitan developments and their interaction may be obtained.

(2) *Provide for courage in new planning pilot studies.* Commission in the way of pilot studies a truly comprehensive planning of one or more metropolitan areas without involving metropolis related authorities on the sponsor end. In this way, the metropolitan challenge can be taken on without any risk on part of the officials who are accountable to the public.

On the other hand, carefully selected teams would be given the chance to proceed really from scratch as far as the development of ideas and concepts is concerned. In the second phase of such a study, ideas and experience would be integrated according to the planning concept outlined above. Only if we understand and can see our metropolitan potential will we insist upon the reorganization of our means.

If such studies could be commissioned for more than one of the existing metropolitan areas, the factors of individuality could be demonstrated more strikingly; for example, what will and can San Francisco-Oakland versus Chicago or New York be 20 years from now? What is their function within the framework of socioeconomic activity within the United States and the world, and how best can it be expressed?

(3) *Cape Canaveral of urban technology.* Select a city in which possible applications of science and technology can be perfected in pilot applications and demonstrated for the benefit of other cities.

In this city, a permanent center for the development and application of technology to metropolitan problems should be located. It also should serve as an urban research clearinghouse.

Simultaneously, this center could be used for educational purposes of future officials and planners.

(4) *The world is yours.* Study systematically foreign science and experience in city planning and metropolitan technology. Socioeconomic research abroad enjoys a high reputation. In other countries, many agencies, associations, and publications with well-qualified research staffs do exist which concern themselves with urban phenomena. They too might be working on problems with which we wrestle.

(5) *In research too, money is coined "power and freedom."* Investigate alternatives for financing metrooriented research on a permanent, integrated, and sufficiently large basis. Research to bring results needs organization, permanence, and drive. The best example is NASA.

The operating expenditures of cities currently amount to $12 to $14 billion annually; the annual expenditures of all local governments are estimated in the neighborhood of \$36 to \$38 billion. The operating of our urban areas is big business. It should and must be possible to allow research, more than ever before, to contribute to the solution of our metropolitan problems.

PANEL DISCUSSION

Louis B. C. Fong: It is interesting to note the parallel between the community problems and the areas of study by the NASA scientists on closed ecological systems. Both are involved in the study of water supply and purification, of air supply and pollution, of waste management, and of sanitation and safety.

In the problem of water pollution, we are familiar with the fact that certain modern detergents contain phenolic structures which are not apparently degraded by the bacterial filter beds of the soil. We are hoping that NASA in its study of biological purification of water might be able to come up with results that are applicable to a current problem in some communities—leftover detergent that has shown up in the water supply.

Of interest is the experience of an industrial plant in Bound Brook, N.J., which has the rather difficult task of treating hundreds of thousands of gallons of waste water per hour before dumping it into nearby rivers. The present system is to dump a bacterial sludge into the impure water which biologically degrades its chemical impurities. It is hoped that some of NASA's work may have projections in the purification of waste water from industrial plants.

In the problem of air pollution, NASA is working on the use of algae to remove carbon dioxide and other contaminants from the air in space cabins.

In waste management we need the help of a physiologist, because we would like to convert the waste into life sustaining components. While we may not, in our community problem, be forced to go as far as a conversion, certainly we may learn something in the area of waste disposal from this work.

In the area of safety the cushioning we must give our astronauts might find some applications to our safety problems here on earth.

Dr. Fred Singer of the Weather Bureau made a prediction that in the very near future the Weather Bureau might be able to forecast weather a year in advance by using the data received from meteorological satellites. This would be most useful in cases where we could foresee a drought and be able to take preventive measures ahead of time.

Finally, another example came to my attention very recently from NASA's Langley Research Center. It concerns the study of the emission and absorption of sunlight. NASA is particularly interested in preserving a reasonable temperature within some of the space vehicles. Langley researchers found that by using a coating of amorphous phosphate they are able to reduce considerably the equilibrium temperatures inside. By varying the thickness of the coating, they could control the temperature range from 15° to about 190° C. It may be possible by projection of this type of thinking to exercise thermal control over our housing in the future. This is particularly applicable to aluminum siding and aluminum roofing because this particular coating is being applied to the skin of our Echo satellite balloons.

Dr. Robert A. Solo: Some people have called this the age of the "overkill." I am afraid it is also the age of the "oversell." Every few years we seem to be handed a new shiny set of keys to the kingdom. Here you are—just go over to that door and put the key in and turn it a little bit, and up the corridor, up the stairway, and first on your right—there's heaven!

The real danger of the "oversell" is that what is oversold tends to be eventually undervalued. I am a little afraid that this is true of what a lot of people think about space and the space effects on urban development. It can be oversold and, if it is, it will end up by being undervalued. The real issue that is involved in our discussion is not what space research has to offer to the city, but more specifically, what the city is able to use of that which space research offers.

The question, as I see it, which this conference is trying to answer is simply this: What has space R&D to offer in solving the problems of the city? Consider the implications of this question. The implication is that the city is an effective organization for the solving of problems. Some cities are solving problems of crime control, of education, of taxation—but they are not effective organizations for solving problems at the level of science and creative technology. Yet they have to be if they are going to make use of what NASA offers. In spite of what Mr. Fong says, NASA is not going to solve the problems of the city. NASA research may offer or may generate some information relevant to the solution of those problems. In order to make use of that information, a number of things are necessary.

First of all, the problems have to be formulated in such a way that they can be meaningfully handled by scientists and creative engineers. Second, there have to be problem solvers trained in science and technology who are dedicated to the needs of the city. There has to be an organization supporting such research whose members are capable of evaluating the answers of theory against the criteria of practical and political feasibilities and capable of translating these answers into effective political action. There has to be an organization of men and money capable of translating ideas into social innovation. When you have that kind of an organization, you can reach and make use of what science is making available. I think in creating such an organization, the city of Oakland could render this country a service.

Robert D. Bugher: The big problem, it seems to me, is to have people who are adequately familiar with space and scientific developments, and who are, at the same time, aware of the economic and political functions of the urban areas. That type of person is hard to find today.

The American Public Works Association in 1955 recognized the need to do something about getting new scientific developments applied in the field wherever possible. We set up a research foundation, and we had proposals for all kinds of research, including getting water out of rocks. A whole host of ideas were submitted. One of our problems was to determine where we should put our money. We had a lot of difficulty getting money in the first place from municipalities who were not accustomed to risking money in research.

We did undertake several projects in which cities throughout the country felt they had a common interest. One of them was on snow removal. We were successful in getting over 60 cities to contribute funds to undertake a major research project of some $100,000, and that study is now underway. This indicates that cities are willing to put up money to study and solve common problems.

There were many such projects submitted. Our Board of Trustees wanted to find the ones into which we should put our money. For that reason, we undertook to make a study of research needs in the public works field—which covers water supply, sanitation systems, highways, and so forth. For this study, Ford Foundation gave us some $40,000. It is now nearing completion. One of the things we found was the lack of people who could suggest and implement the kind of projects that were really new concepts in an urban society. There are a great many new techniques available, and I believe there is a need for the type of research that will apply that knowledge to our problems. As an example, most people do not realize that the Federal Government is spending millions of dollars in research on gaseous and liquid wastes and methods of handling these wastes—but that there are only about $70,000 being spent on disposable solid waste. It should be pointed out that solid-waste disposal accounts for about $2.7 billion a year for the collecting and disposal systems. We could stand a lot more attention in this particular area.

It would be most economical to dispose of the waste on the spot, and some people think this can be done through on-site incineration. Some of the complications are the odor problems, the air pollution problems, and the fact that individual householders are not able to make proper adjustments in operating these units. It seems that there should be some possibility that new space technology could be applied to regulate these units by remote control—or could suggest other means to eliminate the need for handling these materials. Saskatoon, Saskatchewan, recently adopted an ordinance requiring these incinerators. This, I believe, is the type of research that is needed to go along with the strictly technical type of research that NASA and many other groups are doing.

Dr. Warren J. Kaufman: I am inclined to identify the problems first, and then go in search of the science, the knowledge, which will, perhaps, provide the solutions. There is no question that in identifying the problem, one has taken a major step in its solution. On the other hand, if we identify a great many solutions—through masses of research and scientific contributions—we may not have solved a single basic community problem. I do not propose in this discussion to identify these basic community problems, but it certainly would be helpful if we give some attention to their identification.

My own personal area of interest is in water supply, water treatment, and pollution control. We might ask ourselves: What has been the relationship of science—and particularly recent science—to these areas? There have been two kinds of relationships. On the one hand, science has certainly created problems in water supply and pollution control; a great many of the things we have been concerned with in the last 25 years, relating to water, are the results of science. In particular, chemistry and the nuclear sciences have introduced new pollutants into water. On the other hand, to what extent has science contributed to the solutions of water supply and pollution control problems in the community? One thing it has done is to give us instruments by which we can perceive, find, and identify the scientific pollutants. In this respect science has been of considerable advantage in the analytical area.

This capability, however, is a two-edged sword, because often we are able to perceive and yet not understand or interpret the significance of what we perceive. Detergents are a very good example. We have a standard for detergents, based not on foaming which is our primary concern with it, but on the presence of chemicals identified by a particular test which may, or may not, indicate its foaming characteristics. The same is true in the area of insecticides, herbicides, and various organic chemicals. We have very elegant, very exacting methods of identifying these. Yet, our epidemiologists and our physiologists have not been able to identify the true significance of these in our water. We assume that because they were not there before, they must be bad. We have a great deal of epidemiological work to do before we can identify the relationships between some of these newer materials in water and the livelihood and well-being of man.

In the area of process changes—the better way to treat waste—science could make many new contributions but, so far, little has been done. Basically the methods of water treatment today in the majority of our communities are truly not very much different than they were 20 years ago.

In the area of science and energy, I feel that we are going to make some breakthroughs, particularly in the field of atomic energy where, potentially, we may open up some new resources. Saline water conversion, for example, is primarily an energy-dependent problem.

Benjamin Linsky: The problems of air pollution are many and varied. For example, smog has actually been found in a submarine. The first long-range submarine had some actual Los Angeles type smog in it. Some of the hydrocarbons came from paint which, though hardened, was still releasing hydrocarbon vapor. In very low concentration, with a small amount of ultraviolet radiation from the fluorescent lamps, there was a photo-chemical reaction causing eye irritation and the polymerization of droplets which resulted in haze.

Our atmosphere has been likened to a sewer. Actually, it is far more like a river or an ocean. Not much can be done about the total atmosphere. The only way to keep it clean is to keep things out of it by changing the methods that keep releasing materials into it, or by simply catching materials as they are released and converting them to something else.

I think there is a need for advanced training and education facilities to turn out air-pollution control agency executives. The time has come when we should do this through formally organized curriculum. I think also we need to review the existing air-pollution control programs in each major metropolis in the world, noting common factors and making better, clearer statements than are now available in regard to both the technical and social-political problems. The proposal that Dr. Wolf made for a truly comprehensive metropolitan community study that is multidisciplined is a fascinating idea.

We are using the products of space and science developments in our air-pollution control work. We have actually written into an incinerator regulation in the Bay Area a standard which utilizes and spells out gas chromatography as a method for limiting some of the hydrocarbons. We would like to use more of the instrumentation that has been developed, particularly with the kind of reliability that has been built into both the outer space and underwater space systems. For the few air-pollution control programs in the country that have any instruments at all—and there are less than 35 of them in the entire United States—an "automatic" instrument requires full-time care. Poor reliability results because the market is so thin that no manufacturer can afford to build, for us alone, instruments with the kind of reliability we need.

Dr. Wolf reported that water treatment costs about $100 to $125 per capita. In air pollution, control agency costs are 5 cents per capita a year for poor systems and 50 cents per capita for good ones—and there are a few. In addition, to stop open burning dumps—used in most communities around the country—and substitute with sanitary land fill, which costs about $1 a ton, amounts to 25 cents per family per month or $3 per family per year. This is roughly a dollar per capita per year. Where you have too far to go for open land that you can use for sanitary land fill, the costs are $5 a ton or roughly $4 per capita per year plus the related capital costs.

The crankcase device being put on automobiles will cost about $5 capital expenditure and about $5 a year for replacement and service. Allowing two persons per car means a per capita expenditure of $2.50 per year; and that just takes care of the 30 percent of auotomobile exhaust which is easy to handle. We are still looking forward to a device which will decrease or eliminate hydrocarbons and carbon monoxides. Oxides of nitrogen will be controlled by second- or third-generation devices. We hope the space cabin developments will produce some good nitrogen fixation methods that can be adapted and applied both to automobiles and to large powerplants.

GENERAL DISCUSSION

William S. Foster: I know, of course, that Dr. Wolf is well aware of the vast differences in the various metropolitan areas. However, the fact that there are differences should not stand in our way in attacking the problems with all the scientific tools available.

It would be intriguing to take a computer, then assemble the best brains we could get, and figure out all the factors that create the sociological, emotional, and technological problems in a metropolitan area. Perhaps problems such as water supply or tariff could be solved by computer, but I don't think anybody has ever tried it. Of course, they say it is too complicated; this should almost give us the challenge to go ahead. Is there someone who could comment on this?

Alton C. Dickieson: My experience in dealing with computers is that the real problem is programing the computer. If you knew how to program it you wouldn't have to feed it all this material.

Mr. Linsky: Some of you may be aware of the massive 1914 study of Chicago's air pollution. As you go through this portal-size volume, you find what were called "Hollerith Cards" which were so new that they were described in several paragraphs. They look just like IBM punch cards. They were used in reducing the data for that study. I support the point Dr. Dickieson made that programing is the significant factor. I think perhaps there are now some additional disciplines and factors that could be programed which could not have been programed a few years ago.

Dr. Kaufman: In this area we do have mathematical models of the polluted streams. We do have, or have had, an analog model of the delta at the confluence of the Sacramento and San Joaquin Rivers. We have now another analog model of the sizable watershed on the North Platte involving the introduction of rainfall, the operation and construction of hypothetical dams, and so forth. The idea is that we examine the number of alternatives and optimize it. This problem is amenable to that kind of an analysis, and it is very necessary, I believe, that we begin to use it.

Dr. Wolf: I think Mr. Foster makes a very important point with this suggestion on computer programing. Life in a metropolis is very complex. We might devise computer models for traffic flow, or for water supply; however, if I understood Mr. Foster, he wants to go a step further. He wants to integrate those different disciplines that are involved not only in traffic engineering and in waste controls but also those in the entire social and economic field. It might require quite a bit of basic research to determine how you integrate those models and to what degree you can use them. I think such a study is almost a prerequisite to determine where we want to go or where we can go in metropolitan development. We also need to consider the scientific findings that would complicate matters. Science might be used to solve a problem, but perhaps we would create problems in other areas. I think such a basic approach as Mr. Foster suggests would be a tremendous undertaking, but also a very rewarding one.

Dr. Robert Wood: There is some evolutionary work taking place in the joining of the kind of model building that Professor Kaufman analyzes and the probable political-social reactions to it. It operates primarily by the coupling of the attitudinal survey with the choices and the cost benefits that the economist and the engineer can develop. It is operating in a minor manner in a land development study of Greenwood. Pittsburgh is on the edge of this in its urban renewal. The essence of this is the idea, simply, to elicit public responses to alternative plans so that decision makers in certain fields have notions of what the reaction will be before they try to change a particular pattern. Problems here are that in the social sciences we are data rich and theory poor. We operate with great banks of data which are very difficult to calibrate and, unlike the natural scientist, with uncertainty as to whether the limited amount of data is feasible for performing elegant hypotheses.

You have to note that we have only had 10 years of the computer and the survey put together, so that some future might be possible.

Dr. Solo: I think the computer is a fine thing, but there is also something of a mystique in the computer, as though it were a kind of magic—you wave the wand and solve problems. The computer is an automated abacus. It shuffles data very quickly. What you are saying essentially is, "We can solve our problems by shuffling data real fast." You cannot.

Dr. Llewellyn M. K. Boelter: I have several short comments. First, I advocate the formation of a Chamber of Professions in each community, which will parallel the Chamber of Commerce. The purpose would be to get the attorneys, the M.D.'s, the engineers, and the professional scientists together to identify the problems, present solutions, and serve as the interpreters for our politically elected officials.

Another point is that it is beginning to cost a great deal to live in the city. We may have already reached the point of no return. What we should begin to talk about is what we can do to a city to make it not only a better place to live but also a more economical place. Unless we begin to take this view we can talk endlessly and there will be no new ideas for the development of the future city.

A third point is that the city *can* be put on a computer, a very large computer. I don't believe one has yet been built, but it *can* be put on a computer as an engineering system. The city is a sociological system and an engineering system. The engineering part can be put on a computer to determine the optimum arrangements of such distribution systems as power, water, and sewage in a given organizational society at a given place.

One final point—which may not be germane to this conference—is that we have not learned how to govern ourselves in large units. I do not think that our large private companies have shown us the best example of how to operate in large units. I do not think that our large cities are properly run. I doubt that our Federal Government is in the best order in this regard.

It was fine for a population of 25 or 50 million. When nations reach a population of 200 million, basic questions of government begin to arise. Those problems will also have to be solved before technological change becomes acceptable.

Roy Sorenson: These problems of water supply, of pollutant solids and liquids, and of refuse disposal call for larger geographic areas of treatment than our fragmented government will permit. With 85 cities and 800 to 900 special districts, how can the technologies be best utilized? The comments of Dr. Wolf and Dr. Solo point to what seems to me to be a huge gap not only between increasing technological knowledge that will become available and that which can be used, but also between that which is now available but cannot be utilized. It appears that we have organized ourselves in such small fragments as to be unable to formulate the problems to generate the images of the potential, to say nothing about just plain affording the gadgets and the processes that will be required to do it. I think that the scientists can well join hands with the political scientists to see that we do get some cooperative and federated methods of dealing with these problems that are too big for small jurisdictions to handle. Otherwise, I think the split will continue to increase. Scientific and technological knowhow will be growing enormously, but the lag will be due to lack of political organization for achieving their use. I think our problem is primarily political and secondarily scientific.

Dr. Ewald T. Grether: Mr. Fong, doesn't the kind of research engineering required for the cabin of the space ship really force you to do integrated model analyses?

Mr. Fong: The fact is I made a gross assumption that Oakland would follow up this seminar with an integrated multidisciplinary team made up of universities with their R&D competence, industry with its R&D competence, and the city, in order that such problems as economic, industrial, and community feasibility would be fully explored before attempting to apply the new knowledge that the NASA space effort is generating. Now, in our experience to date, we have found little really significant technology that is directly applicable to satisfy an industrial economic need without some process of translation. This is a very necessary process. Anything that has a certain degree of sophistication has a leadtime of say 10 or 15 years, as has been mentioned. NASA hopes that by making this knowledge available to communities and to industry at an early date, this leadtime can be reduced. We do not intend to promise things that can be turned over tomorrow, but we do feel that because we have concentrated our effort in so many special areas, this knowledge can be used by such communities as Oakland at a much earlier date.

With respect to the problems of reeducation, this is a very interesting problem we are faced with in our program today. In our dissemination of potential industrial applications, we have talked about techniques that are 10 to 15 years old. We have found that some industrialists are so concerned with day-to-day operations that they do not have time to keep up with the tremendous push in the state of the art. They find ideas of 10 years ago that are quite usable today to cut costs and improve their manufacturing techniques.

Mr. Linsky: The changes that are being made by a number of industrial establishments in the Bay Area required by law to install air pollution controls have been startling in regard to the numbers of total plant reassessments and reevaluations that have been made by managements with resulting plant layout changes, plant process changes, and material handling changes that overcame obsolescence and production lag. A classic example: a quarter of a million dollar installation investment in air pollution control in a large-production foundry was accompanied by a quarter of a million dollar change in material handling methods. This is just one of many examples. There seems to be a "catching up" at the time of a reassessment for some external reason.

Robert W. Craig: I am very concerned about the "oversell" aspect referred to by Dr. Solo. I think that some of us will certainly admit that the space effort is necessary and that it follows, from what we know of the effort and activities, that some applied benefits will be derived. But I think that to feel that the solution of the pressing urban problems, or problems in the world at large, is inevitably linked with the space effort is probably less than the case. This confusion can result in a failure to deal adequately with certain urban problems that must be dealt with on a program basis. Spin-off, although not necessarily accidental, does not solve problems in terms of the variables that are confronted in an urban situation. There may certainly be some similarity to the problems, and there may be some application.

Arthur N. Fried: It seems to me we've overlooked one basic thing in this whole problem, and that is that the American society as a whole is one big waste-generating machine. Because we have a very high standard of living, we are not only profligate with our resources, but we are lazy. In years past, when we had a farming society, raw garbage was used to feed the farm animals and combustibles were burned by the individual property owner. Also, during World War II, for example, people didn't throw away toothpaste tubes or tin cans. They were reused. Today, it seems that everything in the way of consumer goods is produced or marketed in such a way as to create a waste problem. It seems to me that although it would not be nearly as sophisticated an approach—but certainly an effective one—we should reeducate the American public to be nonwasters rather than wasters.

If the use of detergents creates a tremendous and expensive problem, where is it written that we have to use detergents? We have it within the realm of our technology to clean dishes by ultrasonic means. If the cost of treatment of water to remove detergents were added to the cost of each package of detergent, I wouldn't be surprised but that this would be more than the cost of using ordinary cleaning compounds and soaps and adding to that the necessary cost of water softening. These are very mundane things, but I am just trying to get one point over. If in the United States, for example, all the coffee that was consumed were instant coffee and all the coffee grounds were used in some byproduct at the processing plants, this would eliminate a great deal of waste. And so on down the line.

What we are saying is "Here is the problem, we are creating this waste, now how do we get rid of it?" We never stop to think how to eliminate the waste to begin with.

Mr. Foster: I don't think the American people are lazy. I have traveled in Europe, and I have traveled in the United States, and I will agree we litter a lot. But just because some of those European cities are neat doesn't mean they are clean. I find the American people very hard working. We talk about 5 or 6 percent unemployed—but 5 percent of our people have two jobs. I dare say many people work considerably more than the mundane 35- or 40-hour week.

Does Mr. Fong have any costs on these closed circuits? It offers a possibility for waste disposal. Is there anything that would imply that this is within reach of practical use?

Mr. Fong: I think this is the part we would like to leave up to the organization scheduled to be formed in Oakland after this seminar.

The same situation pertains when we disseminate our knowledge to industry. We don't want to go into marketing research and economic feasibility. We think this is the area for industry to act. In the community problem area, we are mainly citing technical advances that might be of interest in solving community problems.

Peter K. Mueller: I am a chemist in air pollution. Dr. Solo remarked that we are being starry-eyed when we talk about all this research because we don't have the means and methods of translating it; on the other hand, Mr. Fong remarked that we have to translate the knowledge into the urban sphere. Actually, we do have in government today—certainly at the state level, and even at the city level—R&D organizations that are capable theoretically of accepting and acquiring some of the basic knowledge being developed. However, we don't have enough such organizations, and we also find a lot of foot-dragging in trying to find good support. This, I think, is an area in which more discussion could take place. How do we increase the size and capabilities of research and development on the local government level without increasing unnecessarily the cost burden that already exists?

SEMINAR C

What Does the Space Program Reveal About Human Engineering and Medical Research?

Chairman: DR. DUDLEY P. BELL, Ophthalmologist,
Oakland, California

PRESENTATION BY

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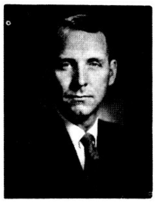

WHAT DOES THE SPACE PROGRAM REVEAL ABOUT HUMAN ENGINEERING AND MEDICAL RESEARCH? [1]

Maj. B. B. McIntosh

The corporate image which we in NASA develop within the next 10 to 20 years affects everyone in the Nation. I am certain that most Americans felt a sense of pride the day after John Glenn orbited the earth, even though they might not have been directly responsible for the success of the space flight. I am equally certain that the image of the Nation as a whole was changed. Our future successes in lunar landings, manned space laboratories and stations, and interplanetary space missions will likewise affect our national image, and our national safety will in turn be directly affected.

We in the directorate of Biotechnology and Human Research of NASA's Office of Advanced Research and Technology feel a great sense of urgency, for we know that the successes or failures of these future missions depend directly upon our research today. This sense of urgency is reflected very succinctly in the words of Dr. Robert Seamans when he laid down the mission of the Biotechnology and Human Research Division:

> Our success and progress in manned space flight in the next 10 to 20 years depend on the human research we do today. The hùman man-machine and man-system requirements must be determined through research prior to the design of any manned system. The human's capabilities and limitations will directly influence various subsystems of the space vehicle. It is therefore important that work in biotechnology and human research be conducted at an accelerated rate, in order to have the necessary answers for the design of our future aerospace systems.

When this office was established in July 1962, we asked ourselves, What organization and research program must we set up to provide NASA with the human research to establish the requirements for the development of an adequate life support and protective system for man's survival in the aerospace environment and the determination of the man-machine relationships, and what type of program will allow us to integrate these requirements into the advanced aerospace system?

The answer obviously was not to conduct random research on body systems, on human performance, on life support systems, and so forth. We knew that if we were going to accomplish our objectives, we must first of all establish the parameters of our research program.

The first step was to establish an interdisciplinary organization composed of biomedical, biophysical, nuclear engineering, and design engineering personnel. We became systems oriented in order to accomplish the planned NASA goals of providing the broad technological and research base for manned aerospace systems. Next a mission and systems parametric analysis was performed to determine the organization and program required to fulfill the mission of biotechnology and human research. Consequently, the possible future missions that NASA will be expected to perform, such as a semipermanent orbital base, lunar base, and advanced aeronautical systems, were examined. A mission analysis was performed for each of the possible future missions.

Next the various system complexes involved in the missions were examined closely (table I). In fact, we looked at the specific systems within the complexes. Within each of these specific

[1] This paper was prepared by DR. EUGENE B. KONECCI, Director, Biotechnology and Human Research, Office of Advanced Research and Technology, NASA, and presented by Maj. McIntosh.

systems we found that our program must include the study of man, man-machine, and man-systems. These three aspects of the program will be discussed individually.

The horizontal parameters of environment—the requirements, the bioengineering, simulation test and evaluation, and advanced concepts—are involved in each of the three program elements.

In man or human research, man's body systems are studied in relation to the total environment. For example, we must study the total spectrum of radiation and its effect on body systems, not just cosmic radiation. This, in turn, imposes certain design requirements on equipment that is needed to do human research. These requirements are translated into specialized biosensors, which are then utilized in a specific environment to obtain data. Those data are then transferred to specific situations where they may be put under simulation test. The next step is to evaluate the equipment, and it may be necessary to go to advanced concepts in order to solve the problem, since it is possible we do not have the equipment or data that are required to answer these questions. The same is true of the psychophysiology, which is really the mental and physical aspects of man. The method of analysis is the same as for body systems.

Once the physiological and mental limits necessary to establish the design requirements for man's equipment and habitability have been obtained, they are imposed on the next area, which we call man-machine or biotechnology. This includes life-support systems, protective systems, and man-machine control. We go through environment, design requirements, and so forth, as we did for man body systems.

After considering the parameters from environment through advanced systems, we establish design requirements for the equipment. Finally, this equipment and the requirements of man are translated into the next area, man-

TABLE I.—*Biotechnology and Human Research Program*

	Environment	Requirements	Bioengineering	Simulation test and evaluation	Advanced concepts
Man:					
Body systems	Environmental physiology	Biomedical design	Bioinstrumentation monitoring	Human performance	Human capabilities and capacities (Cybernetics)
Psychophysiology.	Capabilities and capacities Habitability				
Man-machine:					
Life-support systems.	Environmental control	Man-machine design	Ecological subsystem	Man-equipment performance	(Bionics)
Protective systems.	Safety				
Man-machine control.	Information displays Controls				
Man-system:					
System analysis	Mission functional performance Reliability concept	Man-system design	Integral ecological system	Man-system performance	Advanced manned aerospace systems; e.g., hypersonic transportation and high thrust nuclear
Human factors	Personnel Task equipment Human engineering Maintainability Training				

system integration. We again consider the overall system that is involved with the environment, the various systems requirements, and so on. The proof finally is in our hands when we put all of these together to test them and demonstrate a workable system.

To give a general idea of the specifics of the systems analysis, table II shows only one aspect, the matrix on human research, specifically body systems—one variable under human research versus environment. Body systems are composed of the integrated total body, including the cardiovascular system, the digestive system, and so forth. These are plotted in relationship to the environment. We have shown only a few selected examples of the environment—acceleration, atmosphere, radiation, and thermal.

Let us take an example of the cardiovascular system in relation only to acceleration, one aspect of the environment which may be defined as a task area requiring research (table III). We then may have to go to this level to obtain more specific data—and here the cardiovascular system breaks down into many subdivisions, of which a few are mentioned here—the heart, the coronary arteries, and so forth. Meanwhile, acceleration breaks down into a number of subparameters, of which only a few are shown in table III.

All of these factors, when added together, make up a tremendous total number of tasks and interactions that must be considered if we are to evaluate those variables that affect man. We find that we have something like 12,500 task areas. An example of a task area would be the total nervous system versus the radiation spectrum. This radiation spectrum would include cosmic rays, ultraviolet, infrared, all the way through to radio waves. These task areas can be

TABLE II.—*Body Systems*

Body systems	Environment			
	Acceleration	Atmosphere	Radiation	Thermal
Integrated (total) Cardiovascular Digestive Excretory Glandular Integument (skin) Musculoskeletal Nervous Respiratory Sensory				

TABLE III.—*Cardiovascular System*

Cardiovascular system	Acceleration					
	Zero g	Sub g	Linear g		Vibration	Noise
			−	+		
Heart Coronary arteries Peripheral arteries Venous system						

broken down into about 187,500 specific tasks. An example of a task is the determination of the effects of solar-flare protons on the peripheral nerves.

This effort is prohibitively large; therefore, it becomes necessary to categorize these various tasks in terms of priorities.

In an effort to establish realistic priorities we had to ask the next question, What data do we now have within each of these task areas and specific tasks, and within what areas is additional research required? This required the services of experts in all disciplines from various sources; for example, NASA, DOD, industry, and universities. It required utilization of various information centers to provide information on research studies accomplished and those in progress. Although the following priority areas are not in the order of their significance, they are all top priority areas as defined by the system and data analysis. These areas are:

1. Psychophysiology of prolonged exposure to zero gravity or subgravity (periods of 1 month to several years)
2. Effects on humans and design implications of space and manmade radiations
3. Advanced integrated life-support systems designed for 1 month to several years of operation
4. Advanced intravehicular and extravehicular protective and locomotive systems for free space and for lunar and planetary surface operations
5. Bioengineering advances in bionics, bioinstrumentation (especially body sensors), man-machine information handling, and display and controls for psychophysiological monitoring and for all-weather manned aerospace flights
6. Advanced dynamic ground and flight simulation techniques and the development of human analogs
7. Selection and training requirements and advanced techniques for flight, ground support, and space research personnel.

The next step was to determine who could best accomplish the research required in these priority areas. It became obvious that if we were to accomplish the task given us we had to use the total national capabilities. This included establishing a biotechnology and human research capability at NASA research centers such as the one we now have at the Ames Research Center in California. Other centers are being used to undertake specific portions of the program where unique capability exists. We are working cooperatively with DOD, AEC, and other Government agencies. Universities are conducting human research, and industry plays a major role in all aspects of our program—human research, biotechnology, and man-system integration for various aerospace systems. It seems appropriate at this time to discuss some specific research which we are supporting in the priority areas.

Psychophysiology of prolonged exposure to zero gravity and subgravity.—Studies of these problems were conducted through the Department of Defense at the U.S. Naval School of Aviation Medicine. This research included studies on the mechanisms by which force fields produce disorientation and functional disturbances by their effects upon the semicircular canals and otolith organs of the inner ear. Studies are being conducted on etiology, incidence, symptomatology, prevention, and therapy of vestibular sickness, ocular illusions, and disorientation in space flight. This research also includes a study of parameters directly related to the astronaut program to include a semicircular canal and otolith function in zero-gravity flights.

Advanced life-support systems.—The NASA Manned Spacecraft Center at Houston has been authorized and funded by this office to study the development of life-support systems just beyond those of Project Apollo, that is, to 30 days. This was done to bridge the efforts of NASA's twin offices of Manned Space Flight and Advanced Research and Technology, so that advanced support and protective systems could be developed concurrently for future approved operational manned projects. This office has recently completed negotiations with the Boeing Company for a completely integrated five-man, 30- to 60-day life-support system. It includes atmospheric control (superoxide), water, food, and waste management and will be demonstrated about June 1964.

As part of our program, Langley Research Center recently requested proposals from a number of industrial firms for the design, fabrication, and test of a prototype 6-month life-support system for four men. In-house studies in progress will determine the design requirements for a 1-year life-support system. This advanced system will be contracted in fiscal year 1964.

Advanced dynamic ground and flight simulation and development of human analogs.—A study by Drs. Jack Findley and Joseph Brady is underway at the University of Maryland's Department of Psychology to determine the capability for highly organized task requirements and the performance of humans for extended periods of time. A 35-year old man has been in confinement in this experiment continually since November 17, 1962. He will remain in this task indefinitely. In his small three-room enclosure he has limited communication with the outside world, but must gain his daily satisfactions from the internal environment.

A series of tasks, ranging from sleep through physical and complex mental exercises, are performed as part of the daily routine, in a fixed sequence, but at his own rate of speed and time at each task. Psychological and physiological tests of his performance and well being are measured.

Information derived from this unique study will provide answers to many of the questions concerning the psychological and physiological capabilities of humans to withstand the stresses of long-term flights in space and on extraterrestrial journeys. This work is being conducted under a NASA grant and is supervised by Dr. Stanley Deutsch in our office.

It must be emphasized that much of our research program is being accomplished with ground-based research facilities. However, it is recognized that certain critical areas such as prolonged weightlessness, space radiations, and duplication of psychophysiological stresses cannot be simulated on the ground. This research will have to be conducted in flight. For this reason, a variety of flight projects are presently under study to accomplish this research. The "Human Factors Systems" program within our office has been outlined. However, at the same time, through the systematic parametric analysis, we feel we have identified the research program, the program research areas, and the specific research tasks for human engineering, as well as all other aspects of the total program.

The one important advance in human engineering we have made is placing it in its proper perspective with the rest of the total man-system research complex.

Through the systematic approach we now have a methodology by which we identify the research priorities required for the physiological and mental limits of man. These data have enabled us to establish design requirements for equipment. We have then translated requirements into an integrated system. The final proof is the demonstration of man and equipment as an optimized system.

Ultimately, however, we have new missions and new system complexes; and systems will have to be generated. But the research we do today provides us with a broad technological base for these future missions. Our systems may change; we may have additional environmental factors; the requirements may change; but we still build upon our understanding of man.

We are extending our analysis to incorporate the logic matrices into the NASA information centers so that fundamental information we generate through research today will be utilized in establishing design requirements for systems in the future. This source of data will be and is being made available to other government agencies, to industry, hospitals, and so forth, who are doing research into human factors systems. We feel it is only through this approach that we will obtain the maximum utilization of our national life-sciences research capabilities.

PANEL DISCUSSION

Dr. Charles I. Barron: Major McIntosh has done an excellent job of emphasizing the tremendous importance and the size and the impact of the total space program, especially in the field of space technology. This is a systems concept, which he points out was something which hit the aerospace industry rather dramatically about 5 or 6 years ago. He also

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touched very briefly on the role of industry, on the capabilities of industry in assuming the systems responsibility and systems management for the whole human engineering and medical research effort.

I have been associated with the aerospace industry and its predecessor the aviation and aeronautical industry for the past 13 years. I have seen the changing concept of this type of impact upon our companies. This is not to say that the concept of human engineering did not exist in the aeronautical industry prior to the impact of Sputnik and our space age. However, bioengineering as it existed was almost entirely engineering and was very little "bio." It was very difficult to convince our users, the pilots, that any human considerations had gone into the design of their cockpits. As a matter of fact, it was common knowledge that retro-design and retro-fit was one of the most lucrative segments of the aircraft business, and perhaps it still is.

When I joined the Lockheed Aircraft Corporation in 1950, I was the only full-time flight surgeon employed in this capacity by any of the aircraft companies in this country. I mention this only to point out the change in concept, philosophy, and relative importance of the whole medical aspect and its application to our biotechnology. Several years later some of the psychologists began to infiltrate into the business and began to sell this concept of human factors to the companies, with the accent upon human engineering as such. Then, in the last few years, we have seen the concept of bioastronautics, and in the last year or two this total concept of the life sciences.

We have also seen a corollary to this—the change in basic philosophy and product lines within a company. What has this meant, not only with regard to the company but also to the technological capabilities of the companies, and to the socioeconomic life of the community? Obviously the majority of aircraft manufacturers today are really out of the aircraft business as such. In many cases, more than 50 percent of their product lines are devoted to the space satellite business. In some of our companies there has been a gradual shift from mass production, which meant the employment of many thousands of relatively unskilled laborers, to the employment of as many as 50 percent technical and scientific personnel. This has obviously had a tremendous effect upon the biotechnological capabilities of the companies, since it resulted in a relative increase in emphasis on such capabilities. But it has also had some effect upon the communities.

In the changeover to this philosophy, as we see it now in systems flight integration in the biotechnological field, we have more or less had to sell industry on the acceptance of this concept. The aerospace industry is basically an engineering industry, and there is a problem of communication between the biologist and the engineer. Finally—either by deliberate intent in the case of a few companies or by necessity in the case of others where this was forced upon them by the customers—many have accepted the concept of integrated life sciences.

It is difficult to obtain the type of personnel that can perform this work. Actually, there are no institutions at the present time, to the best of my knowledge, that really train biologists to bridge the gap between biology and the physical sciences. There are a few key people in various industries that have assumed positions of responsibility by virtue of their military experience and training. Some companies are fortunate in having biologists who are primarily engineers and who have gone into biology or medicine as a secondary effort. But basically there is no integrated training. There is no manpower pool.

There is a considerable difference of opinion as to where a life-science group actually fits into the table of organization of a company. In most companies this group—since it has to support the products, either directly or indirectly—is placed in the engineering branch, where I think it logically belongs, under a director of research, perhaps, or under the chief scientist. But this does not necessarily solve the problems of industry because of the type of personnel that has to be attracted to the company.

It is difficult, for example, to attract the basic research scientist into an engineering environment. On the other hand, companies insist, regardless of the type of research that is done, that this research be the managed or programed type of research. They feel that this type of research either immediately or ultimately has to support the product line, and this we have to keep in mind. Thus, it has been difficult to integrate this new concept and employ the type of interdisciplinary people we want.

Another basic problem is that of communication. It is very difficult for biologists and physical scientists or engineers to communicate with each other in a meaningful way. The engineer wants data; he wants criteria in order to set up certain design specifications. Unfortunately, many biologists in this field have not yet become industry oriented or product oriented, and this has been one of our most difficult areas. I was quite impressed with Dr. Kimball's presentation on information transfer to the scientific community. We have not as yet achieved this information transfer even within a company to such an extent that we can avoid costly and time-wasting duplication and replication of efforts, because we cannot communicate among ourselves. This has been a major difficulty.

There is also a question as to how much basic research, for example, should be involved in these areas. As system managers, or as potential system managers, we believe that we do have the interdisciplinary capabilities to conduct the type of work that Major McIntosh pointed out is badly needed and dependent upon industry. However, there is some difference of opinion on the part of management as to how far an industry or company should go in the support of this basic or fundamental type of research activity. I think all companies feel that there is a potential need for this in advanced—or future—product lines. Most companies have been community and socially conscious, and as a result they feel that since industry has the capabilities for broad technological advances and the interdisciplinary type of approach, much of the information we gain has direct applicability to general scientific efforts outside the space goals. However, there is a feeling that the companies themselves cannot indefinitely support this type of research and that if, indeed, this is done in the community interest, perhaps the community ought to join the companies in helping to support the research.

We find on the basis of our studies that although we have not been involved in the pure aspects of medical research, we have been actually cooperating very extensively with the universities. We are dependent on the universities for certain psychological and physiological data. There is a need for mutual cooperation between universities and aerospace industries, for the common use of personnel, and for the common use of specialized types of facilities. Surprisingly enough, I found that a good deal of my own time had been spent working on common problems with the research division of one of our local hospitals.

There has been a considerable amount of publicity recently about bioengineering and speculation as to whether biologists should assume an increasingly important role in efforts to modify man himself. Having worked in both the medical and the technological aspects of this, I believe it will be very difficult in the immediate future to make any significant changes in man's ability to adapt to the type of stresses that are anticipated. Our efforts, certainly in the biomedical field, should be primarily to determine man's capabilities in order that we may optimize them within his limited degree of flexibility, and then to convey this type of information to the engineers so that they can translate it into engineering designs for safety. In other words, we must re-create a habitable environment for man, whether on the moon or in interplanetary flight, and the best way to do this in the immediate future is simply to optimize man's performance rather than try to modify significantly his ability to withstand stresses.

George A. Rathert, Jr.: Dr. Barron has commented on the interdisciplinary aspects of this work. Most of our venture into the life sciences or human-engineering area has resulted from the need to understand what we are doing in fitting man into the various vehicles and systems. We started by fitting man into aircraft, and now, of course, we are fitting him into space systems and advanced missions. In the process of doing this, we have had to go into these multidisciplined concepts. At Ames Research Center, for example, in a group devoted to determining what the dynamics of airplanes should be so that a human pilot can cope with them, we have psychologists, electrical engineers, mechanical engineers, systems engineers, and mathematicians—all in a group of 20 people.

This cross-discipline is imposed by the workers themselves. They are insisting on it. Some of the electrical engineers are taking degrees in psychology, an aeronautical engineer is studying physiology, and some of the psychologists are trying to find a good engineering school that will teach mathematical and analytical techniques that they observe their fellow workers using. They realize they can have the work done for them, but they want to do it themselves.

Some of the schools are forming very forceful departments or programs which emphasize this approach. You can go to M.I.T., for example, and take a program in bionics. You can go to the University of Michigan and take a program in systems engineering. In the process of getting a degree in systems engineering, you will be literally in almost every department of that university, which is a very large one. This approach is significant because even the children in the schools are picking up the idea. As we talk to physics classes in high schools, they are asking us what kind of disciplines they can combine to get the future they want and what they need to do to work on these problems that interest them. The universities have possibly not been as farsighted as they should be in this regard, because most of the young men who come to us for employment have obtained these programs only by fighting with knees and elbows to be able to cross departmental lines.

This drive—this need for understanding—that is evidenced in the younger people, who are fascinated with the glamor of the space program, is going to affect us all. Our children are going to be asking for better schools and a broader base of courses, a broader base of equipment. This is one of the ways the space program is having, and will continue to have, a direct impact on urban life.

Dr. G. Dale Smith: I say engineering is to physics as medicine is to biology, meaning that the difference between the applied and basic cannot be defined. There is developing within the life-science capability of the United States a new breed—engineers who are becoming biologists and biologists who of necessity become engineers. But at the same time, in carrying out the program described by Major McIntosh, we must not forget the part that is basic rather than applied. Somehow, during the time that we in NASA are involved in carrying out the thousands of tasks mentioned, we must not let slide the backbone of all applied or developmental work—that is, the basic concepts of biology and physics. Our contracting program within NASA is endeavoring to carry out both simultaneously.

We must do things on a priority basis in order that better information or design criteria may be available for the next series of space vehicles. Also, we are striving to build up the interdisciplinary educational program by granting and contracting to universities. We are building up a very few—hopefully, good—life-sciences groups within the government itself. Approximately 90 percent of our total expenditure will go into contracts to industry, universities, and other government agencies.

Referring to one of Dr. Barron's comments, until recently nothing within the engineering system of an aircraft went beyond the tolerance of man. If the aircraft went too high, we could furnish him oxygen; we could furnish him with a g-suit that would take all the airplane could give before the wings came off. But the vehicles that we are building today can exceed the tolerance of man—hence, our need to study the physiological and psychological tolerances of man. If it were technically and economically feasible to provide 1 g in all spacecraft, to protect the occupants from all radiation, to solve all of the thermal and acceleration problems, and so on, we would have no real mission in the life-sciences area to support such a program as NASA's. To do this with some understanding of man's tolerance and to try to develop design criteria that work man to his limit—using him to his utmost—is the problem today.

GENERAL DISCUSSION

Dr. Bell: At the start of World War II, I was a flight surgeon stationed at Randolph Field where I had gone through flight training. There were so few problems to be considered! They had a g-suit under construction; they had the human centrifuge, a low-pressure chamber, and a few such things just getting started. That was not many years ago. When one thinks of the jump that has been made from then to now, it is astounding.

Clay Bedford: Being a businessman and charged with the responsibility of making some of our revenues exceed our cost, the question that arises in my mind is this: What publications are there, if any, that condense to the laymen's language the developments from the space program which might be utilized for something other than such exotic ventures as going to the Moon or to Mars or elsewhere?

Maj. McIntosh: If I understand your question correctly, it seems as though you're asking whether or not we make an effort to take our research and development findings about humans and equipment and translate them into applications—outside applications. I must say, first, that all of our research on human-body systems will have direct application to everyday life.

Some of these "fallouts" I can mention. We made a study of the human body which may give us some information on aging. The study of the frequencies of the heart to try to anticipate any abnormalities may have fallout for the medical world. The development of small biosensors—the size of a dime or smaller, that could well be imbedded—is a fallout that we have in the biomedical field.

The fallouts that we will have in the equipment field are many and varied. One that is now under contract is a small TV camera, the size of your hand, that we will use to monitor human performance. One could go on and on about the fallout that we will have from our research programs. In NASA all of the research groups, and the operations groups as well, send their findings directly to the Office of Applications, and they in turn have the responsibility of insuring that these findings are fed to people who can possibly utilize them in the outside world.

Dr. Smith: The scientists who are either under contract or within our laboratories are encouraged to report their findings in open literature, medical journals, and other scientific journals throughout the country even before they are usable by NASA.

Mr. Bedford: My question really was: Is there any summary published, or must one go to the Office of Applications and keep constantly in contact with them? In other words, how do you minimize the time that it takes? There is no question but that you will develop an immense number of improvements. I wondered if you had some publication that spreads the information in a simple way.

Dr. Smith: There are agencies set up for the dissemination of this information through the medium of ASTIA, the American Institute of Biological Sciences collection service, and, just starting, a Documentation Incorporated collection service that presumably can be used by the private individual as well as by the company or government employee.

Maj. McIntosh: Our matrices are being tied into an information center called Documentation Incorporated, which NASA has under contract. It will search all the literature in the country, as well as Russian literature. For example, I may want to ask them: What is known about the heart under zero g? They will essentially select this information for me from ASTIA, the Library of Congress, the School of Aviation Medicine, and so on. They will then provide me with what I want in terms of either abstracts, total hard copies, or a summary of research to date. Our contractors also will be provided with this total package of research data from the past, research projects that are going on at present, and the state of knowledge as of this time. I think that we will receive one-third more research for our money because people do not have to search the literature.

William S. Foster: I was interested in Major McIntosh's reference to the man in a capsule because it has a bearing on our urban life today. As you know, we puzzle over how much living space each individual should have. We consider, generally, 120 square feet of living space as a minimum figure. In other parts of the world, this figure is reduced to around 90 square feet. We have areas that we consider slums that provide more space than that. Now, you have a man trapped in a capsule for a long time, and evidently happy. How much living space do you provide him? Is there any special consideration on that that might have application insofar as we analyze these things?

Dr. Smith: I think the room they have him in—and he is not "trapped" because there is a door he can open any time and go out—is 10 feet by 11 feet with one small room off to the side, about the size of a telephone booth, with a toilet. On the other side is a similar room that we call the "playroom." Actually it has a typewriter computing system on which the man can work problems to keep himself happy.

Mr. Foster: That would be about 150 square feet.

Dr. Smith: Something like that. This was designed for two people, but the experiment is being run with one man alone until they are sure about him. Another will be introduced later.

Dr. Barron: Let me point out that it would be very difficult to take some of the experimental data that is obtained by using highly motivated individuals as subjects and equate it to urban life. Remember, in designing we design for one of three things. First of all, at one end of the spectrum we design for comfort; and for a passenger train or vehicle, the comfort of the passenger as well as his safety is important. Our second consideration, probably in military mission accomplishment, is to design so there is no performance degradation of the individual. As every military pilot knows, we have sometimes compromised comfort for the sake of safety and adequate performance. The third design condition would be that associated with highly experimental conditions where we have to design to assure the survival of the individual. Obviously putting a man on a couch for a great many hours is compromising a high degree of comfort, but he is in a habitable environment and we hope we can bring him back at least safe. You should not extrapolate some of these experimental conditions to the urban type of life.

Benjamin Linsky: To what extent are you planning work on your 3-month, 6-month, and 1-year exposures with respect specifically to induced stresses to maintain alertness, and to what extent are you planning to work on questions of leadership and group behavior comparable to those in the submarine?

Dr. Smith: In the programs for developing the life-support systems that are going on at the present time the group-behavior question is being studied, but the investigators are not interposing a lot of other stresses in the testing of this system at this time. It is planned in the future to have life-support systems that can dynamically simulate all the degrees of freedom we can on earth, and interpose these stresses.

The real test will come in utilizing the information gained to build these systems and to study the individual components of man's behavior. In this system, the ultimate will be in the manned orbiting laboratory, where we can do research on stresses of space, on the relationship of man with other men, and so forth.

Mr. Linsky: It is in this area that I see a great potential for a "dropout" in useful information for community operations as well as for industrial, occupational, and group organizational operations.

Dr. Smith: I think you are right.

Dr. Bell: Of all the thousands of problems that there are to be solved at present, what is the most difficult problem that you have, medically speaking, from man to instrument?

Dr. Smith: It is the communication between the men that they are using and the instrument makers themselves. It is a communication problem. That is the largest problem we have in trying to build up the information from man to an instrument read-out method of some sort. Did you mean: What is the biggest problem we see in developing instruments to physiologically or psychologically monitor man?

Dr. Bell: In general, I was thinking of the biggest problem in making man and a machine the perfect unit that it will be some day. I wondered what is the biggest problem to overcome in that man-machine venture.

Dr. Barron: I am not sure we can isolate one single problem and call it the biggest problem. First of all, our basic need is a better understanding of man's psychological and physiological capabilities. Despite all our research in the past, we are finding out as a result of the space program that actually we know very little about the human being, especially about the total performance—the total system reaction—of the human. We have studied various component parts of this system, and we understand a little about the liver and spleen and some other organs, but we do not understand very much about the integrated person as a whole, about his performance capability. We do not understand, for example, how he performs under certain conditions of multiple stress because we have never been able to duplicate such a situation in a terrestrial environment. We will never understand how a human being can tolerate prolonged zero-gravity until we actually expose him to an environment of this type. We cannot do this in a terrestrial environment. All we can do is postulate.

I participated recently in a discussion at the California Medical Association on a panel called "The Role of the Urologist in Space Medicine." Frankly, I had never known there was a role of the urologist in space medicine until I was asked to comment on it. The panelists were all a little concerned, mostly about sex but about a few other things, too, such as the possibility of calcium-phosphorus metabolism difficulties under prolonged weightlessness. When bone is in a weightless environment, apparently there is a demineralization, and this to the urologist means such things as the formation of kidney stones.

They are also interested in other things, such as flow characteristics and the effects of 100-percent oxygen upon renal functions. These are problems which are just beginning to evolve because we are beginning to expose people to stresses like that, and we are beginning to learn. We do not know how they will react to other situations because either they have never been exposed or we cannot simulate these conditions on earth. So, basically, we have to have a little better understanding of the total integrated individual as well as the component and subsystem actions.

It was pointed out that one of our biggest problems is in the field of bioinstrumentation and sensors. There is an even bigger problem—we are not even sure what type of physiological measurements we want. How can we tell the engineer to develop instrumentation when, as medical people, we cannot even tell him what is and what is not important?

We want indices of failure; we want to predict failure of the individual. We are not interested in how long it takes his heart beat to go up to 180. This is a normal situation for people under stress and is not a deterrent to performance, as evidence by the fact that all X-15 pilots have developed this rapid heart beat rate, and they have performed very well. It is meaningless to get a pulse reading under stress conditions or conditions of hypoxia and find that a man reacts by having his pulse rate go up to 180. It tells us nothing. We do not know the significance of these things, and until such time as we do, it will be difficult to get adequate and meaningful types of bioinstrumentation. To go back to the question, the answer is that we have to understand a little more about the total psychological-physiological performance of man, and then translate this into design concepts and specifications, to integrate the man first into the machine and then into the entire system.

Dr. Smith: This comes back to my original statement that medicine is to biology as engineering is to physics. Although we have progressed very far within the last hundred years in both areas, we do not understand the mechanism of many of the successful treatments in medicine. A bridge can be overdesigned to accept all anticipated loads, and the designer need not understand the conditions under which it would fail. Much of the medical research in the past has been based on disease and its cure. Many aspects of the normal physiological functions of man were not studied because they were not relevant. We are in a position now to find out how little we really know. The biggest problem is finding out about man himself.

Bernard Haber: In your very fine answer to this question, you triggered another question. This has to do with the entire field of psychology, psychiatry, and the behavior of man. You specified "under stress," but to my mind it is basically the behavior of man.

It has been quite a few years since Sigmund Freud propounded his theories. Since then, the whole field of psychiatry and psychology has received a great deal of attention. And yet, we still know relatively little about this subject. I am interested in your collective opinion as to whether we can extrapolate the performance of man to any long-duration missions in space; whether the processes that the country uses for selecting astronauts are really so constituted as to give us some assurance that specimens used here will indeed live up to the environment that they are going to be exposed to.

Dr. Smith: It is my opinion that if man fails in a long mission it will not be from the psychological aspects but from physiological aspects. Psychologically, man can adapt to do almost anything he wants to do if his motivation is in that direction.

Maj. McIntosh: I will not necessarily disagree. However, we in NASA Headquarters feel that, to answer this question, we will have to have a manned orbital research laboratory to check out the multiple stresses that man will be subjected to for long duration. We do not have now a way of finding answers to this question.

Mr. Rathert: I would like to throw in an engineering input to that. The extrapolation from some of the theoretical considerations of human behavior, to predict what is likely to happen to a certain group of people confined for a certain time on a certain mission, is a very dangerous thing. Many papers have been written which, if taken literally, would indicate that submarines should not leave their home base and that B–29's should certainly never go on 24-hour refueling missions. I think the use of the orbiting laboratory or actual checkout concept is the only reliable method. The human test pilot—or the professional vehicle-and-systems handler, if you will—is a different "breed of cat" from the "average person" that has been studied academically for a number of years. The performance of these pilots is constantly amazing us. We can do confinement studies; we can induce certain effects that indicate there are very serious problems, using test populations made up of average individuals or selected by some one index or another. Then we can throw in an experienced test pilot or B–29 or B–47 pilot and upset all our results because he just sits there and does the job. Motivation is the primary thing. If the experienced professional is motivated to do the job, he will do it—and he will upset all your theories about such things as cubic feet per man and auxiliary equipment to amuse and entertain him.

Dr. Barron: I do not quite agree that psychiatry is a science. I do not classify it as a science, but I will try to answer your question. Some of the very finest test pilots—not very many, but some—and some of the most valorous soldiers have been severe paranoiacs, for example, We are really concerned about the whole business of personnel requirements and testing at the present time. This is undergoing very critical evaluation. We are not entirely sure that our method of selection is proper. Perhaps it was for the work we have to do at the present time. It is difficult to answer the question, again, because we are not quite sure what the stresses are. As long as they remain unknown, we have to begin with the concept that these types of flights require people of certain types, with certain basic skills and with certain capabilities which may have nothing to do with personality types whatsoever. They will have to have certain amounts of courage which you may also call motivation. I will certainly agree that this has made the tremendous difference, in many studies, between success and failure—personal motivation on the part of the individual.

Earl Johnson: Discussion of motivation brings up another point. As one considers the discussions of this conference on space, science, and their impact on urban life, one tends toward the conclusion that behind it all is the dollar. When you see proliferation up to 187,000 projects in a very narrow area of the conference and consider the length of time NASA has been in existence, and then extrapolate into the future the growth in the budget of NASA, you begin to wonder whether the necessary motivation is present in the urban dweller to raise the amount of taxes necessary to pay for this.

Obviously, everything that is being investigated here is essential for the success of the mission. Obviously, there will be a tremendous amount of fallout which can be utilized for the good of industry and for human life. But is there not some kind of time scale that needs to be observed from the standpoint of the generation and formation of capital to take care of this study? In 1962 the budget for the Defense Department was $56 billion, which happens to exceed the gross national product of France. You begin to wonder what you can afford to do. I wondered if anyone engaged in the research end of the business would care to comment on this?

Maj. McIntosh: Yes, I would. This is the reason Dr. Konecci was not here today. He was testifying before Congress—selling, essentially, our research program to representatives of the American people. They ask very critical questions. We ask ourselves questions, too, concerning what it will take to reach our goals—and our goals are quite well defined for us in terms of obtaining research on the body systems and setting up design specifications for equipment in order to accomplish these missions. We look at the dollar figures too, in terms of accomplishing research. This is the reason we went through this systems analysis in total. We defined all the tasks, and then we narrowed them down in terms of what tasks we have to do to accomplish our mission of getting to the moon or to accomplish interplanetary missions. Then we asked how we could save money on these priority tasks. We proved to our satisfaction that the best way to save money—or get the most for our money—is to provide the contractor with a stack of information that is available from Russia and from America.

We have charts which show a drop-off; that is, a great deal of our work will be completed by 1965, in terms of body systems and in terms of specific missions. Much of our equipment for specific missions will be developed by 1965. We have set these as some of our goals. We believe that once we get the basic information, expenditures will drop off.

Mr. Johnson: When you look at what has happened in the past, in order for a research dollar to be transformed into a successful piece of hardware, you must ultimately multiply that research dollar by a very large factor—and this applies to the full spectrum of disciplines. Add to that the fact that the complexity of the resulting vehicle increases vastly. You may be in the position of hastening research and bringing into fruition the vehicle but, because the money has all gone into research, finding yourself with none left for the vehicle.

Dr. Louis Winnick: One of the panelists indicated that life science is almost a new branch of medical research—that for several thousand years, medical research was addressed to pathology, to disease and its cure. Here you are looking not only at what might be regarded as health, rather than disease, but at the upper limit of health. You are not trying to test representative men, but perhaps the upper 1 percent by some standard of performance. You are engaged in performance tests. It has been my experience that performance tests—whether in industry with light bulbs or in biological and psychological experiments with rats and other animals—are always based upon a premise of variances. That is, no two performances will ever be identical even though the specimens possess similar outward characteristics, but most experience will follow some kind of normal distribution. Therefore, only a certain probability statement can be made about the performance of various types of specimens under consideration.

In the space research experiments Maj. McIntosh talked about, you put a man in a cabin and there he is quite happy. The question of motivation is always present. It is very difficult to extrapolate from this experience a probability distribution of performance for the next hundred men that go into space—or the next thousand. Your research, instead of being perhaps overexpensive or overbudgeted, is still vastly underbudgeted. You really will not have reliable findings as to performance under the space stress conditions of isolation until you obtain a probability distribution by performing this experiment over what would be regarded by any statistician as a fairly usable sample.

SEMINAR D

Developing and Maintaining Open Channels of Communications Between the Laboratory, Industry, and the Community

University of California, Berkeley
Chairman: JOHN R. WHINNERY, Dean, School of Engineering,

PRESENTATION BY

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PANELISTS

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DEVELOPING AND MAINTAINING OPEN CHANNELS OF COMMUNICATIONS BETWEEN THE LABORATORY, INDUSTRY, AND THE COMMUNITY

Dr. George L. Simpson, Jr.

It seems to me that this topic, which is quite general and broad, might be broken down into three categories. I will dwell only briefly on the first two because they have been developed earlier in this conference; I will leave it to the panelists to develop these further. The third category I will consider in somewhat more detail.

The first category is that dealing with communication between laboratory and management—communication between the research people and management people—their needs, their thoughts, their hopes. This is an extremely important problem, not at all limited to private companies and industrial concerns. It exists in Government agencies, such as NASA, in which there are very much the same kinds of problems as between management and research people, or as between headquarters and centers. This problem is also found in the universities as between scholars on the one hand and deans and heads of institutions on the other.

The second category is the mass communication problem. This is the one Dr. Kimball has referred to, the problem of storing, of indexing, of retrieving, of making available to research people generally the great inundation of information coming from a wide variety of sources. I do not have the answer to this problem. We in NASA have a program which we are pushing vigorously; other agencies of the government have their programs. The government as a whole is seriously involved in bringing more out of its own operations. The same trend is reflected also in private industry, in the academic community, and elsewhere.

The third category, to which I would like to address myself especially, is that which relates to the general focus of this conference on urban life and on the problems of these great metropolitan communities in the matter of their access to, their awareness of, their use of research and knowledge—the application to their situations of the best that we have. Let me review what I think has been happening in this country and why this problem has a particularly sharp relevance.

As previously mentioned, we have in this nation moved to live in great metropolitan centers and in their associated hinterlands. In this movement, we have in effect destroyed old values and old patterns of doing things. We are in the process of working out new values, new patterns of living together, new solutions to our problems—some of which are old problems, perennial problems, some of which grow entirely out of this new ecological arrangement, this new concentration of life that we have moved to. We are, I think, evolving a new type of locality, a new type of local interest, a new sense of somehow having to solve problems at the local level, including the problems of the large metropolitan city.

The attack on these problems is in part a matter of research, of getting the data, of intellectualizing. It is in part a matter of study, in part a matter of engineering, in part a scientific matter. But before, during, and after these things, it is essentially a social situation—a matter of working out in our social relations, in our understandings, not only the things that should be done but the acceptance of them and the capability of putting them into effect.

Much of this conference to this point has been devoted to what science—particularly the NASA program, but also science in general—

can contribute to the solution of transportation problems, air pollution, and all sorts of specific problems. Yet I wish that in this seminar on communications between the laboratory which I interpret here as being our source, our base of knowledge, and the community we might also maintain a clear-cut regard for those social relations involved in establishing communication in terms that are useful to these people who have suddenly flocked to our great cities.

I suggest that there are three essentials in this process of bringing a great metropolitan community—Oakland, for instance, its neighbors and relatives—into a useful, effective relationship that will facilitate the communication and use of the best knowledge available from scientific research. The first element is this: There must be built into this situation that we are living through a source of knowledge and research that is not ad hoc, that is not called up always by crisis, but one in which the people involved either have or can develop confidence. We must think not only of the intellectual content of the new knowledge that might help solve problems, but, because we are dealing with great masses of people in these metropolitan communities, we must provide a source of information that has the confidence and acceptance of the people of the community. Effective communication leading to local action cannot be provided through a national organization. It requires a local source in which confidence may be built up throughout the community. Now, there are dangers here, of course—parochialism, among others—but I do not think that we can get away from this basic necessity. This must be a source that is above reproach, a source that keeps itself clear of involvement in partisan matters—and yet, as discussed subsequently, it must be a source that is related closely enough to problems and to action agencies so that it is not "ivory towered."

What might be some such sources if we were to start today to seek them in Oakland or any other metropolitan community? In what directions would we look? To some of you it might occur that one source that has been widely used in this nation—one that has done so well that it is about to work itself out of business—is the agricultural experiment station and its associated extension work. Here a communications network is built into the local level, with research established at least on a state level, often on a regional level also.

There are others we might consider. What about planning agencies? Is this a source? Can this be a source for bringing to the people of a metropolitan community the best in knowledge, of performing research, of commissioning research? On the whole, while there has been some success, I don't think experience indicates that planning groups provide all the answers.

Much of the information that we act on or don't act on at the local level is provided by ad hoc citizens' groups. Here again, I don't know that we would want to depend on this. On the other hand, we might want to examine the possibilities of a set or group of citizens' groups—some now established in the framework of the metropolitan community—that would, over a period of years and on a more permanent basis, work at various problems.

We might also look very closely at the establishment of a research activity in the metropolitan community government itself. Although there are many examples of this, I think we would probably agree that success has been limited.

Another direction in which we might very well look—and one which may hold at least the beginning of the long-term solution—is to the university. It seems to me that in this pattern of the future that is developing, the core of the metropolitan center is, more often than not, a university situation, and I believe this relationship is going to extend. The university is becoming increasingly important in our lives in many new ways. So it may very well be that the pattern of the future will involve establishing confidence in a university, in a metropolitan situation, as that source through which the best of knowledge, research, and information is brought to bear on the problems of the community.

Now the immediate reaction to this will be, "This is not what the university is for—this is not the very core of the university." I would agree at once. What we are discussing is a social situation, however, and social situations change. Also, there is always a social context for our institutions no matter where they are. The university may very well be drawn into a new level of joint activities with the metropolitan community in which it exists.

Let me give an illustration here from my own home situation in North Carolina. In that State, the university has played a rather general part, but at the same time a specific one in terms of programs, as a source of information, as a communications link between the people of the State on one hand and the best of our knowledge on the other. This has been done in a variety of ways, and its success is really rooted in the history of the State. I do not in any sense consider that "spin-off" from experience in this essentially rural situation applies directly to the new metropolitan situation. But let me indicate what kind of thing has happened there.

About 25 or 30 years ago, there was established with much pain and anguish what is called the Institute of Government in the University of North Carolina. I say "in"—that is not entirely true. It was established "in relation to" the university by a man from the law school whose dream it was to go somehow into all the localities and counties and cities and, quite simply, read the laws to the sheriffs and the clerks of courts to bring order into the administration of justice in the State, especially at the local level. This Institute was organized not apart from the university; it maintained a very close relationship with the university; it maintained, frankly, the independence that university association gave it. It did not become an institute dependent on public support apart from general university support, nor on private or foundation support. It achieved the ability to move out into the area of government improvement and reform on its own terms. I emphasize this point primarily to indicate that this keeps this kind of source of information above reproach. It is on this basis that confidence can be built. Here there is a very delicate line between, on the one hand, being merely a study organization and, on the other, taking action which does not become involved in partisan or factional disputes to the death of the organization.

Over the years, this particular organization has been extremely effective both in maintaining a viable, proper relationship to the university and at the same time, becoming a link in communication—that is to say, first transferring the best of information to the local groups and later, as that State and all other States began to centralize in taking statewide action, becoming in effect the staff to the general assembly and to the government. It has functioned not only in the strictly legal sense, but in a wide variety of activities that range from planning, zoning, to government reforms, tax reform, to the study of matters relating to highways, transportation, to pollution control and water supply. What I am indicating here is not necessarily the solution, but it is the kind of thing that must be built into the evolving life of the metropolitan communities—leading toward access to, use of, and confidence in a source of information, a pervasive source and eventually a long range source.

However, it is not sufficient to have the best sources, even a source in which there is general and nearly complete confidence. Somehow a source of information, of communication must be tied rather closely and insistently to a structure of action. Communication must be sharp enough and focused enough to be acted on; the best source of information can only give information. To be effective it must be brought very close to a structure of action.

Let me give an illustration. The present Council of Economic Advisors is at once a source of information with a specific directive and a part of the structure for governmental action. Because it is built into this structure, its study, its work, its communications cannot be ignored.

In the metropolitan community, there must be established in the structure of government a mechanism by which the best of the information that can be brought to bear on community problems is so related to the structure of government, the structure of action, that it cannot be ignored—not that the information must be accepted, not that it must be applied. But the mechanism must be such that the information cannot be ignored in the normal course of that community's life and action.

Finally, there is the motivation that must be developed to obtain action. The general experience has been, and will continue to be, that in the areas of public action—particularly those involving the application of new knowledge to a particular problem—concurrence and action are normally attained only under the stress of some extra motivation. Citing once again from my experience, we had three communities which tried for a number of years to come together to develop a metropolitan system of government, particularly with regard to transportation and water problems, including a disposal problem. There were many studies; much information was communicated. But there was no structure involved. It was only after a particular structure, in this case an ad hoc structure for general economic development, was set in motion that it became possible to see possible solutions for these problems of metropolitan life. Beyond that, specific economic advancement began only after there was some brick and mortar in a particular activity. This area was then able to establish a metropolitan water commission, to attack jointly the problem of water, disposal, and transportation.

It is this that I refer to as motivation. I don't know if this can be in any sense planned for or structured in the way that the first two elements that I have discussed might be, but I think that in this evolving metropolitan situation motivation cannot be ignored.

PANEL DISCUSSION

W. Kenneth Davis: I would like to comment on the problem of communication between the laboratory, industry, and the public, primarily from the point of view of an engineer, an engineer who is trying to make some practical application of some of the things which are coming from the laboratories and from theoretical research work. Certainly one of the key points is that the engineer, as distinguished from the scientist, is concerned with economics; he is concerned with cost. I distinguish somewhat between economics and cost because one has to look beyond simple bare cost. The engineer is generally oriented towards some type of economic or cost system, and he is also faced with a problem of being able to make some practical application of what has been discovered.

In general, the engineer finds that although many things come out of the laboratory, most of these are treated very optimistically and then are found to have numerous practical problems in their applications. There are certain problems that generally arise. For instance: What can you make the things out of? How long will they last? What will they cost? The laboratory work is often not directed towards these more or less practical problems, and, as a result, much of the work that might otherwise be of value cannot really be translated into useful commercial products. I'm thinking here primarily of works from government laboratories, and sometimes even from industrial laboratories, in the applications to industrial products and processes.

Scientists and engineering scientists often do not feel that they have any particular obligation to "sell" their ideas to those who are perhaps likely to make the commercial applications. In fact, they would much rather talk to each other and write a lot of articles which perhaps only they read. In many cases there is simply no feeling of responsibility by the laboratory people that it is part of their responsibilities to "sell" their ideas. They seem to feel—and this is a generalization which is always hazardous—that if their ideas are not recognized and put to use by someone, then this is the other person's fault and not theirs. This difficulty has been somewhat recognized by those responsible for extensive programs such as the NASA program and parts of the AEC program. Some people recognize that unless they are able to sell the value of the program, the program is not likely to continue on the present scale for any great length of time. But I am somewhat concerned that, unless some real transfer of information can be made and some practical uses made, the public is not going to be sufficiently concerned to support the program too long. Certainly the scientists in the laboratories are going to have to do their part in helping to effect this communication.

People often assume that information can be transmitted simply by preparing reports and by sending them to someone, or by compiling a great mass of information and making this available. In the area of development, as distinguished from that of research, there is an absolute necessity for experience in doing this type of development work—individual experience or experience in the company or enterprise that is going to make a practical application. There is a need to have access to the people who have done the work, to see the work, and to go through the process. This means that the mere compilation and dissemination of reports, often out of date and in a language which is difficult for the practical engineers to understand, is simply not adequate for a transfer of information. Often there is a tendency to place developmental programs in Government laboratories or universities with the expectation that somehow the information coming from them can be readily applied to industry. This is a very fundamental difficulty in many parts of our system, because if we truly expect commercial and practical applications, the only real way in which this can be done is to have the people who are going to make the application actually carry out the development work. It is simply not going to do any good to have the universities do it and then hope that some industrial company will pick it up, or to have the Government laboratory do it with the same expectation. You can do it for fairly new fundamental ideas; but when you get into the area of development of techniques or processes of importance, this kind of a transfer is going to be extremely difficult. I think it is responsible in many cases for the obviously slow transfer and utilization of the $10 or $12 billion worth of research and development that is supported by the Government every year.

Dr. Smith J. DeFrance: I agree with Mr. Davis that the prime purpose of any scientific investigation is to "sell" it and not just to report it. Fortunately, in the scientific community we have wonderful opportunities now for disseminating information among scientists through professional meetings and journals of the societies. But I have been wondering whether we are using that facility to the best advantage. In many instances it appears that the scientist is more interested in talking and getting his name in print than in what he writes. One goes to some of the technical meetings and sees the same people speaking on the same subject under a different title. In that way we are flooding the scientific literature and contributing to the problem of information retrieval. I think that scientists and engineers—in their communications not only among themselves but with industry at large and the public—need to be more selective in the material they produce and try to "sell."

An observation on another point—in the National Advisory Committee for Aeronautics, predecessor of NASA, it was our policy in working with industry to do the research and turn over the results of our research to industry to carry out the development. NACA did practically no development. Although NASA has been getting into the field of development and hardware more than in the past, I believe it is still our intent to contract most of the development to industry. I hope we can establish the same good communications we had under NACA for delivering that information to industry and to the academic community for their use.

As to communications with the public, I think it is very commendable that the mass media have changed since 1958 so that they can now really bring a message to the people of the country. At the time of Sputnik, I think the average man in the street, reading the popular press, didn't know what the writers were talking about; I wonder if the reporters who wrote the articles knew themselves what they were talking about. I think it is very commendable that since 1958 they have made wonderful improvements, enabling the man in the street, as well as the youngster in junior high school, to understand. I can see that the public must understand the space program—for the space program involves one of the largest expenditures of money that we have had in this country or in the world. We have to "sell" our product to be supported by the public.

Dr. Weldon B. Gibson: It is characteristic of this process of communication that it takes a transmitter and a receiver. There are two or three points in that general context that I will cite.

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First, in connection with the general idea of transmitting from science to industry, one of my associates and I have been engaged for a number of years in the study of the processes of planning for the growth and development of industry in this country. We find that, of about 3,600 of the largest companies in this country, about 20 percent have some organized means of planning and assessing the impacts of science and technology on their future growth and development. We have stated a law from this work: Problems in industry and in management increase faster than the means to solve them; but good planning can help close what we call this managerial gap, and in closing that gap, the surveillance of the state of the art in science and technology is a very important function.

With respect to the matter of transmitting and receiving technical information, it seems to me that an exceedingly important aspect of this problem is that of transmitting to the technologically underdeveloped industries, or those that are nontechnologically based. An example may illustrate what I mean. In 1950, some of my associates and I were engaged in a long-time conversation in San Francisco with a large company in a nontechnologically based industry. Later, we checked our transmitter and found that: yes, we had the power; we had the right frequency; but something was wrong. We soon realized that the receiver was turned off. That very day, I had a 4-minute conversation with one of the participants in that meeting in which I asked him if his receiver was open, if he was prepared to receive a message. When he said, "yes," we described to him the idea which finally led to the ERMA development. The application of electronic recording machine to accounting is now, I suppose, the greatest technological development that has occurred in the field of banking. I think this is a great example of a transfer of technology into a technologically undeveloped or a nontechnologically based industry. But while there are more and more transmitters open now, one does have to find the right key.

With respect to the universities on the one hand and industry on the other, I commend to you the example of Stanford and its Honors Cooperative Program in which an effective link is being formed between industry and university in the scientific and technical fields. I believe this is being done without any diminution of the quality of either the academic teaching or the research. In fact, because of the sound financial manner in which the program is being established, it is enhancing both sides. There are increasing instances—particularly where universities are surrounded by large technologically based industries—of joint faculty appointments in industry and in the university. It seems to me that this is a practical way to make sure that our receivers and our transmitters are working and are on the same frequency.

Now, while we are aware of the necessity for increasing the applications of science and technology in this country, there is also the broader scene involving the whole international area. We have two major developments occurring in the world—very rapid increases in population in countries that can least afford it, and very rapid decreases in the numbers of people engaged in agriculture. The developments of the past 50 to 75 years indicate to me that one of the major problems in this world is: What will we do with the people who flee from an increasingly efficient agriculture. One can find examples of this all over the world. As time goes on, the same problem that we are feeling is an intensive way in this country—where less than 10 percent of our people now remain with agriculture—will encompass parts of the world where now, 75 percent of the population is engaged in agriculture. I think this is one of the fundamental problems in the world. The fact that this is being increasingly realized around the world is perfectly evident from the major impact of the meeting in Geneva on Science and Technology in Underdeveloped Areas. There were 1,800 papers there, and the principal problem that has evolved is how to boil them down in order to get an effective transfer to people who have their receivers on.

Dr. Willard F. Libby: It seems to me that I can add one thought to those that have been put forward—that is, that we may find it helpful to foster and encourage adult education programs. I have been very impressed at UCLA, where I teach, with the 10,000 people who come to school every night. Last year, I signed up for a course in Space Science. It cost $100 to do it—for me and one of my graduate students. There were 300 other people paying $5 a seat each week for 10 weeks for a 3-hour talk, and it was a good bargain.

I don't think any one suggestion is the answer to a very broad and difficult problem that has been placed before this conference, but I do think adult education—the idea that you've got to keep going to school—is one we have to consider. We will accept that we have to continue to read about and to study new developments, but sometimes it is difficult to comprehend by merely reading. The matter may be too complicated or may be too new to reach over into our experiences, and so it may be necessary to go back to the classroom. The technique for adult education and extension programs is pretty well known, but it might be a good idea to use it more generally and on a larger scale. I don't cite this as "the" answer, but as one of the things that could be added to the list.

There has been particularly direct experience in this matter in the atomic energy work. Here was a development as new as space—perhaps in some ways newer—which has tremendous potential for the community. We are going into the atomic power age at a rapid rate. We have tremendous growth ahead of us in this direction. We have received large numbers of benefits from radioactive isotopes and radiation; but every one of these could be multiplied by a dozen if the average technical man understood isotopes and radiation or the potential for movement of earth by atomic explosions. So, we have in atomic energy one of the very best examples of what this conference is about. But, despite all of the effort the AEC has expended toward wider use of atomic energy, it has not accomplished a perfect job. I think the organization has done a pretty good job as far as information is concerned. It placed the material on shelves of the libraries—you can get it if you really go after it. But this is an example of why you can't always read something and comprehend it. I think we ought to consider more extension work as one of the several things that can be done to help solve this problem.

Dr. John P. Nash: The problem of communicating between scientists and engineers in the community is not a new one at all. It is one on which every industrial concern has spent a lot of time and effort—and I think that so far, most industrial concerns will agree that, as yet, they haven't even begun to solve the problem of communicating between the people in their own laboratories. Those of us who have been in industrial research and engineering management for any length of time have all had the embarrassing experience of finding that two of our laboratories—perhaps even in adjacent buildings—were working on the same problem, and no one knew anything about it. It is not the kind of thing we like to admit, but it does happen.

We worry about how we can get our research ideas into development and how we are even to find out what the research ideas are—because many of the best ideas that come out over a period of years are ideas that result from research programs which were intended for quite different purposes. We don't know how, on a broad scale, anybody gets access to information so that from a new context, ideas can be used in a new way.

The first requirement is that the people who are working on these things—and this has been said over and over again, I merely want to reemphasize it—must be working in an environment in which they know where their ideas are going when they are developed and how these ideas might be developed. There isn't a place any longer for the isolated research laboratory, and if we do have an isolated research laboratory these days, it certainly is going to die. A research man has to be somehow in the mainstream of the activity of his organization—and this is not an easy thing to do, either.

My second point is that there has to be a determined effort in communicating between technical people. This sounds rather trite, but it really isn't. Unless some scheme is worked out or some plan is made whereby the new technical ideas are transmitted in, shall I say, the less technical directions, we will fail in our communications. We have discovered in our own activities that we cannot count on the engineers to make the effort to get their ideas from the research people, or the manufacturing people to get their ideas from the engineers; it must work in the opposite direction. I think the same thing is true in working with the community. As these technical ideas develop, they must be transmitted to the community. One way is with the adult education program that Dr. Libby has suggested. I think we are making quite a lot of progress in this direction now, because it is certainly true that communities are becoming much more technically oriented than they used to be.

There has to be an active interest by the community in what is going on in the research laboratories and in the development laboratories. The community no longer regards the research and development people, or other technical people, as miracle workers, or as people who, by means of witchcraft, develop remarkable new ideas. The community is learning that research and development people are really people like themselves who work hard at their jobs and achieve their results in ways that are not at all miraculous.

I think the team approach of research and development is, in general, going to help the communications problem—and they are rare problems indeed that are worked on in our laboratories in the universities, or in government, or in industry that are not attacked by fairly large groups of people. An electronics problem might be worked on by metallurgists, ceramicists, perhaps statisticians, chemists, or maybe occasionally an electrical engineer. Here, communications within the group itself can be a problem. We have found that such communications problems are best solved by having the people work together on the reports that are prepared.

Referring to Dr. Kimball's remarks about Ph. D.'s who can't write, I think this is one of the severe communications problems. Our technical publications organization has difficulty in talking to scientists and engineers. And scientists and engineers often don't realize that the only thing they have to sell in many cases is a piece of paper. If the piece of paper cannot be read, then the results are not very useful.

Dr. Simpson made the real point, as far as I am concerned, in connection with this communication problem. The point is that the communications problem is a sociological problem rather than a scientific one. I think the problem can be solved only by developing a mutual confidence and understanding between the technical people on the one hand—who must realize that the community at large has a right and a need to know what they are doing—and the community on the other hand who must try to understand, through these various other techniques that have been mentioned, exactly what is going on in the laboratories. We can help communications by using computers, automatic abstract-making devices, language translating machines, and the like. However, I believe mutual understanding is the key to the communications problem.

GENERAL DISCUSSION

Robert D. Bugher: I would like to suggest that it might be useful for cities to appoint scientific advisory committees to work with local units of government, particularly in the larger metropolitan areas. We have undertaken studies which clearly indicate that our people—professional public works people such as the street superintendents, the superintendents of water and sanitation, and so forth—are not sufficiently familiar with new technological developments to propose useful research projects. On the other hand, we have evidence that there are many people in the scientific fields and in industry who aren't very familiar with practical problems at the local level. There is a gap here that can't be solved by conferences now and then. It takes a prolonged association of people with these different backgrounds.

About a month ago, I attended a meeting of the American Society of Civil Engineers in Atlanta, Ga., on Environmental Engineering. I think that civil engineers are beginning to understand that they need to have a broader background in economics and sociology. One of the students who spoke at that meeting indicated that he went to the school of economics and took some courses, but they were taught in a way which was not very practical for him, and he didn't get much out of them. I think this is a real communications problem. The courses have to be presented in such a way that the student can see useful applications in order that he can put them into effect. Again, I would suggest that there is a place for a scientific advisory committee to municipalities which could be made up of people from universities who are going to be teaching these students. I think the university people would themselves benefit by that. I also suggest that public officials and their experts could attend such meetings and present their problems for consideration by scientifically minded people—again to the benefit of all.

Robert H. Ryan: In order to provide a linkage between the new ideas coming out of the scientific laboratories and the problem of economic growth, we have a group in Pittsburgh composed of 10 scientists from 3 institutions—Carnegie Tech., University of Pittsburgh, and Mellon Institute. The group advises us—"us" being a quasi-public development corporation, financed publicly and privately—as to three things: First, the new scientific ideas that have industrial development potential to the region; second, the merit of scientific ideas that we are willing to finance by providing risk capital for new incubator situations; and third, the identity of the "Dave Packards," the "Ed Lands," and the "Varian Brothers" of the future so that we can find them and finance them. We have been doing this for only 6 to 9 months. The results are good, but I would not be prepared to stake my life on them.

The efforts of this group are coordinated by a full-time Ph. D. atomic physicist who is an interdisciplinary guide. As an individual and part of the staff, he is devoting a major portion of his time to developing the linkage between the local corporate research laboratories and the universities and nonprofit research facilities in the area. We are doing this as an experiment. We have high hopes for it. We trust that we, as an organization, will in time develop the kind of support—basic, massive public support—which is vital if the program, of which this example is only one facet, is going to pay off.

Alton C. Dickieson: Of the billions that go into R&D, the great bulk of it goes into development—and the great bulk of that produces hardware which is of no use whatsoever to the civilian economy in that form. The job really, it seems to me, is to translate it into that missing link. This is a development job of picking up those ideas and translating them into the things that our friends from the "De Facto Corporation" can use.

Dr. Nash: It is the problem of finding the ideas in the laboratories that were used to develop these things for special governmental programs that may have application elsewhere besides the Government programs—and this is a very hard thing to do. Many companies have people with broad backgrounds in science and engineering, whose job it is to talk to the laboratory workers and try to learn from them the things that perhaps the laboratory workers themselves didn't realize had applications in wider fields. This is only in its infancy in many places, and it is hard to do.

Louis B. C. Fong: A particular corporation which faced the problem of intercommunication between physically and geographically separated laboratories originally held seminars which involved many man-hours of effort; they have now resorted to the simple device of film strips—very short film strips—in which they go directly to the laboratory and let the laboratory innovator describe his ideas in very simple terms. Collections of these short films are used as the intercommunication means between one laboratory and the other. It works out beautifully. I think their record of growth and innovations supports this technique.

Arthur N. Fried: From the standpoint of communications, I would like to draw attention to the problem that was faced within the DOD. For information dissemination, there are something like 300,000 scientists and engineers working on DOD-sponsored R&D. For these scientists and engineers to communicate with each other would require something like a million and a half communication channels. By centralizing the information source, the number of these communication links has been drastically reduced.

The same thing might be applied to a specialized information center for handling or relating science and technology to the solution of urban problems. Perhaps this could be done through some type of institute which would be established by the banding together of cities. It seems to me that urban communities tend to "go it alone." I think the time has come for them to join forces, because the majority of their major problems are common—air pollution, transportation, sewerage disposal, and so forth. The solution to a problem for one city would find application in many other cities.

Such an institute would mean a small per capita expense, but I think the return would be tremendous. It would have in it those people who have the technical ability to draw upon the information sources and relate this information to solutions of problems, meaning urban problems.

Dr. Robert A. Solo: I wonder if there is any merit in the idea of NASA taking the initiative in preparing courses covering new aspects of space science to be given at various levels—the college, the extension course, and the high school.

Dr. Libby: I think there is considerable merit in that. The AEC did something similar. There have been a considerable number of courses on the latest developments in space, science, and technology, and books do exist. But things move so rapidly that the books must be continually rewritten. It is a continuing job to keep these things up to date—which, I suppose, is up to NASA. We do, of course, have to have schools giving these courses.

Dr. Solo: There is a problem of bringing into the curriculums of the university a very rapidly evolving science, isn't there?

Dr. Libby: Yes, but there is a way that you can solve it. In the course I mentioned, there was only one professor from UCLA, and the other 9 or 10 professors were outsiders brought in specifically for this course in space science. The university can serve as a center for this kind of activity. You need not have everybody doing the teaching on the staff permanently.

Dr. Simpson: We do have a rather extensive program in this area, seeking to put out a variety of materials that will be useful at various levels. We begin with materials prepared for elementary and secondary schools, including the spacemobile program which is superficial but is a start. Then we do have a rather substantial program of working with colleges and universities in the area of teaching methods, of summer training for teachers, and so forth. We also have a constant flow of materials, of booklets, of pamphlets of one sort or another. However, this is a broader educational problem. Space science has to be put into the broader stream of education for science, and we are taking some steps now that will relate us more closely to the general stream of science education.

Dr. Reynold M. Wik: In this conference we are aware of the constant reference to the need and to the importance of transferring knowledge among all segments of society. We are also concerned about the lag period of 10 or 15 years required to implement an idea. We are talking about putting out ideas and materials in educational fields. I am wondering if one of the problems might be that we have a bottleneck in the field of copyright regulations.

As you are aware, when anything is published, we have stamped in the front of the material: "All rights reserved." Similarly, if we submit a paper for publication and it is accepted by one publisher, it is limited to publication by that one publishing firm.

Here is a very definite limitation upon the use of information. If one is teaching in the classroom, this problem becomes a real one—you are not permitted to mimeograph material because the rights are reserved.

Probably not all companies reserve rights, and some material is readily available. I am suggesting that on some occasions when we submit information for publication, we encourage the publisher not only to stamp on the material "All rights reserved," but to add "This material is important to the advancement of science and technology, and therefore, anyone is welcome to use it in any way he pleases." I don't think this kind of liberalization of copyright usage would either make economic chaos for the publisher or harm, particularly, the writer's significance. I think we do have here a blocking technique in which frequently the most important articles are limited to the journals with the smallest circulation. This works contrary to the wide dissemination of important scientific and technological information.

William M. Harrison: Just an observation: Those of us who carry a measure of responsibility in the urban area find it exceedingly difficult to transpose ideas into action. I wish the universities would concern themselves with this and perhaps help us.

Mr. Bugher: I would like to comment on a suggestion that was made earlier concerning a kind of research institute. Our organization, the American Public Works Association, set up a research foundation several years ago. The basic purpose was to provide the means and machinery by which research could be undertaken in this field. The whole idea is to have cities come and present their problems to the foundation, and we also have a number of research ideas submitted. We, in turn, go to other communities to find if the ideas will be of interest to them, and they put up the money to finance it.

One project is underway now at Armour Research Foundation. We have about 15 cities that are putting in money to develop a device to monitor continually fly ash emitted from an incinerator stack. Public Health Service is matching the city funds. Unfortunately, we haven't enough money yet to finish the project. We have contacted instrument manufacturers to see if they have any interest in supporting this kind of research. Our experience so far has been negative. When we try to get support from industry, they usually indicate they have their own research program underway. If they can see an opportunity to get patent rights, they will be glad to put up some money; but they are not willing to join together with communities in helping to finance research. At least, this has been our experience.

Dr. Llewellyn M. K. Boelter: There are several comments that I would like to make. One is that I want to thank Dr. Libby for telling about our program, which I believe is the most elaborate program in the United States in developing and transmitting information to the people in the field, and in bringing information from the field to the students who wish it. I invite anyone who is interested in a program which is working to look into it.

I think that this matter of not looking at the information that is available and using it, say for municipal use, has a root that is very deep. If we look carefully at knowledge, we know that its source is from the past. It is from the immediate past and the present, and it has to do with the productivity of the research laboratories. I think you will find, if you study carefully the way in which university curriculums are set up, that most of the energy is expended in presenting materials which are from the immediate past or from the present and that we have overlooked entirely all the lessons from the past, just as we are now almost overlooking the lessons of the future. We must be very careful about this whole matter of how we sift the information for use. I think it is important for this conference to have in mind that we are talking between two ends. One end has to do with the resources which this Nation has, or which all nations have collectively. The other end has to do with the needs of the people—and we are in the middle of this. We are talking about something halfway between.

My other point is that it has been brought out several times that the way to get people to communicate with each other is to throw them together and to reorganize them. I think a very important and basic issue is that we recognize once and for all that "knowledge for use" and "knowledge as generated" are organized differently. This is why professional schools and universities exist. They exist because their function is to reorganize knowledge. The knowledge that is produced by the scientist—who works in a certain way, who reasons in a certain way, who produces his information in a certain form—must be reorganized for use. These adult education courses are designed for exactly this purpose—to reorganize knowledge for use. I wish to stress the difference between organized knowledge as generated and organized knowledge for use. They are very different with entirely different vocabularies.

Louis O. Kelso: The whole field of technology relates to the production side of the equation, the production of goods and services. If we could take every usable scrap of knowledge out of the space program, or any other advanced technological program, and apply it to the civilian economy, we would produce a vast amount of goods and services. But, the interesting point is, we cannot even consume what we produce now. We have very few industries that operate at more than two-thirds capacity. That is not the whole story. I come from the world of finance—I tell you we could double the capacity of any industry and redouble it a dozen times over. So, the problem isn't a problem of translation of information. I don't think it is the central problem.

The problem, as several people have pointed out, lies in the field of the social sciences. The physical sciences have outstripped the social sciences—outstripped law, outstripped economics, outstripped politics, outstripped finance; they are miles ahead. They are not in the same antediluvian world in which the nonphysical sciences flourish. I would suggest that the thing we should do is to attack the problems in the social sciences. Open up the demand for the products, the goods, and services that we could produce if we applied our productive knowledge! Then I think you will see an incredible transfer of knowledge. It will be soaked up so fast that the world will change not just 3 percent a year or 5 percent. I think it could be a 100 percent. But you have got to open up the demand side of the equation. We can't concentrate all on the supply side and solve the problem.

SEMINAR E

What Specific Implications Does Expanding Technology Have Upon the Problems of Metropolitan Areas?

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PRESENTATION BY

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WHAT SPECIFIC IMPLICATIONS DOES EXPANDING TECHNOLOGY HAVE UPON THE PROBLEMS OF METROPOLITAN AREAS?

Martin Meyerson

Every nation must beware of being the victim of its own propaganda. We must avoid being prey to our slogans, to our optimism, to the image we try desperately to project to others.

We in the United States cannot afford to be taken in by our own great expectations for automatic progress through technological advance. The ancient Greeks and Romans in their dramas had a god descend out of the heavens when the hero needed help; this device was labeled the "Deus ex machina"—god out of the machine. Today, we often resort in our thinking to "machina"—just the machine—and expect all things good to be accomplished by machines, new power sources, new technologies of all kinds.

Yet at the same time we are all painfully aware that while we seem to be able to conquer outer space, we are stymied by traffic jams in metropolitan centers. While we are able to transmit messages by closed circuit television, we still cannot get a building inspector in one suburb to discuss—let alone agree on—regulations with the building inspector in the next suburb. While we can devise elaborate input-output tables, and calculate them with speed and detail on the newest computers, we still cannot work out equitable and adequate tax measures to finance local government services and attract competent personnel.

Knowing this enormous discrepancy in problem solving, we are tempted to say, "If we devoted the same talent and money and time and public attention to urban problems as we do to space problems, we could solve them too." I am not so sure that we could. For one thing, many of the urban problems are not technical, they do not have readily discernible objectives, and they do not have manipulatable materials. Urban problems are more often matters of value, judgment, and behavior. If they are "solved" according to the views of some groups in the population, they are unsatisfactory according to the views of other groups in the population.

At the same time, we should not undercut what we are doing in urban affairs or minimize the costs of technological advance. Technology is no panacea, nor are urban studies unexplored wildernesses.

On the one hand, we often forget the huge capital costs necessary to exploit technological advances. Even now, 60 years after the introduction of the automobile, we are just getting a full interstate highway network. We often forget the time lag that so customarily accompanies scientific and technical discoveries: television was worked out a generation before it was introduced on the market. We also often forget the amount of research and experimentation that must be written off as waste effort. On the other hand, although urban affairs—and particularly urban research—are admittedly undermanned, underfinanced, and underdog, there have been a number of excellent studies recently, and they promise to get better. For example, several members of the Joint Center for Urban Studies at M.I.T. and Harvard have been working on problems of technological change and urban life. Aaron Fleisher, a meteorologist and systems specialist, now on the staff, points out in his paper entitled "The Influence of Technology on Urban Forms" that "an adequate supply of water seems to be the only condition that may stunt the growth of cities. In all other respects, a city of fifty million is a reasonable extrapolation." He expects that the relative growth of cities will to some extent depend on their place in the air network. He considers the one-car, one-airplane family to be a distinct possibility. He warns that we are likely to make different mistakes in controlling the airplane than we made with the automobile. He concludes that "patterns of density within a city appear to be largely independent of technological developments."

Richard Meier, who had been with the Joint Center, explores in our monograph on communications and urban growth the kinds of communications systems which cities of different population size require. He examines communication transaction capacities, public controls, the psychic dangers of communications overload, and means of conserving human resources and information. He suggests that there must be vast increases in information storage facilities and in the interconnections between automatic systems if "advanced societies are to increase their organization and capacities for cultural interaction."

We have looked into the problem of whether, under new systems of communication, cities will concentrate or decentralize their economic activities in the future. Raymond Vernon, in his monograph entitled "The Myth and Reality of Our Urban Problems," which grew out of a study of the New York metropolitan area, states that the trend will continue, if not intensify, for people and jobs to locate in the newer and outer parts of metropolitan areas rather than in the old. He thinks that only about 20 percent of the jobs—those for which the communication need is not satisfied by the telephone or other mechanical means—are likely to remain in the older congested areas. He is upheld in these findings by Lawrence Schwartz's recently completed study of the relocation of the central office and its workers. Schwartz found a surprising amount of mobility among office firms; almost one-fourth of all offices sampled moved at least once during the years from 1949 to 1961, and the trend is unmistakably outward. New methods of communication are not likely to reverse this trend.

Robert Wood of M.I.T. and the Joint Center directed a project at the request of the Municipal Manpower Commission to look at the metropolis of the future and the anticipated changes in technology for housing, water, transportation, air pollution, power generation, and servomechanisms and determine what new demands these would place on municipal administration and personnel.

These are some of our studies which are already in the public domain. We are currently working on a transportation study, relating the emerging kinds of transportation to patterns of density and urban form. We are also trying to set up, with Harvard's Public Health School, an investigation of new methods of waste disposal.

I mention these activities which have gone on and are going on at the Joint Center for Urban Studies partly to show that some spadework is being done in exploring the implications of technological change for metropolitan areas, and partly as a reason for not discussing such things as the immediate prospects for prefabrication of housing, data collection and mapping, air pollution problems and control, transportation or the related subjects which might be discussed.

Instead, it may be interesting to consider several other changes which may have even greater impact than these upon life in metropolitan America.

One change is the extraordinary shift in values that is occurring in the developed economies.

Max Weber in his brilliant study of the rise of industrial man, saw in industrialization and the Protestant Reformation, with which he associated it, the transference of the norms of the medieval monastery to the outer world. The rationality, regularity, precision, and devotion to work and study which were characteristic of the monastery had to be adopted by entrepreneurs and factory workers alike if handicraft methods were to be replaced by complex machinery and industrial organization.

In the developing countries of the world, we see the advocates of economic progress insisting on the monastic necessity of the clock and the calendar, on literacy, on set prices and wages, and on other trappings of the industrial world, rather than a personal rhythm, spontaneous bartering and haggling, and other time-consuming practices of the preindustrial world. They preach the values of rationality, devotion to work, and orderliness. However, in the most developed countries, the norms of rationality, precision, and devotion to work, so essential to the original industrial revolution, are being eroded by the new technological revolution. The work day and the work week get shorter and shorter. The coffee break and the lunch conference get longer and longer. The machine has pushed people off the farms and out of the oil refinery and the insurance office. More and more routine tasks are being done—and can be done—by machines; and many complicated tasks seem more suited to machines than to fallible men. New norms of consumption and leisure have become the focus of the latter part of the twentieth century in the United States and parts of Western Europe and possibly Japan. Occupation is no longer the preoccupation.

Is a new hedonism to be the general rule? Will more and more people want to "goof off"—to get by with sloppy performance, to do as little as possible, to get the easy job, and to remain uncommitted to their work? Will their commitment instead be to their boats, their country houses, their pets, their clubs, their television programs? Or will pleasure take the form of more Sunday—and weekday—painters, more night classes, more community activity? The distinction I am trying to make is not between passive leisure—watching a baseball game, for example—and active leisure—participating in that baseball game—but between a work orientation and a play orientation. Just as the original industrial revolution demanded a work orientation, so the new technological revolution encourages a play orientation, whether directed to popular culture or the capital "C" culture of the highbrows. Indeed, our whole economy would falter without the premise of frivolous or playful mass consumption.

If a hedonism of play is to be the new norm, then the great metropolitan centers surely will be the focus for this hedonism. For this is where man can buy and use what contents him. It is even where he can be launched toward the wilds if he wants to escape from it all, ostentatiously equipped with propane refrigerator, air-conditioned tent, and nonfail fishing lures from Abercrombie and Fitch.

In the era of the hedonism of play, the norms of work and study, precision and rationality, proselytizing zeal and devotion to cause are retreating from the larger world to a new kind of monastery—the great university and the related orders of the technological schools, the colleges, the research corporations, and industrial laboratories. Like the earlier monastic orders, the members of the new ones—the professors and researchers—must take vows of poverty. Their vow of obedience to truth has bested boards of trustees and directors and even State legislatures and congressional committees.

Even the administrators of the new monasteries, like their predecessors, the abbots, pride themselves on adding administrative duties to their normal ones. If the university administrator does not continue his teaching, research, and writing, he feels he has sinned.

Today, it is largely the university-based person who is the new crusader, carrying the true word to the developing countries. Armed with the gospel of the computer program, the professor or researcher carries the word around the world. Nor does the new crusader neglect the home mission: witness his work in the New Frontier and his involvement with committees of all possible kinds ranging from nuclear energy to building codes.

Certain important technological changes which have implications for urban life are underway. It will be the new monasteries which will both shape and propagate these changes for the outer world to use and interpret.

Electronic, chemical, aeronautical, and space research capture the popular imagination and a large part of the research dollar. However, it seems that the most significant research which will affect our lives in the years ahead is biological.

We are all concerned about the population explosion. The threat of overcrowding metropolitan areas seems particularly frightening to some observers of California. But the biological revolution may have an impact on our urban areas undreamed of now by those who fret over increasing birth rates and decreasing death rates.

R. C. W. Ettinger of Wayne State University has had the courage to explore the proposition that most Americans now breathing have a good chance of physical life after death. Some will call Ettinger a crackpot. Like most true believers he overstates his position. He says of his proposition: "This fact represents the greatest promise (and threat) of all history, not excepting that of nuclear energy. Since it seems nevertheless to have gone unnoticed, I have appointed myself tocsin-sounder." I shall pass over many aspects of Ettinger's argument. For example, I dismiss his main idea that people be frozen after death and kept in suspension until in some future time new organs are developed. Rather, I think we are close enough to the possibility of substituting man-made viscera for human ones, that if immortality is not within our grasp, at least a span of life many times the biblical one of three score years and ten, is.

Ettinger uses much evidence to buttress his position that biological renewal is impending: the regeneration of tissues and organs, transplanted organs from human beings, mechanical hearts, lungs, and kidneys.

I will pass over the questions of how quickly and how well we will be able to succeed in these biological tasks, and assume that we will be able to master the human body, just as we will be able to master weather at some future time. The big problem is not how many mechanical devices we can turn out, or how cumbersome or comfortable they may be, but how these devices will be allocated. Who will be chosen to live longer than he would ordinarily be able to live? The "Doctor's Dilemma" of George Bernard Shaw—"Whose life to save: the irresponsible profligate genius of art or the steady, upstanding clerk?"—has been taken out of fiction and been put on the real stage of life. In Seattle, a machine was developed that can save only 10 patients a year from a fatal kidney disease. *Which* 10? This is the problem that faced a citizen committee in the Swedish Hospital in Seattle. It is a problem which will become widespread, because however far we develop our medical technology, we will not have the resources or the abilities to prolong life for everyone. Who shall live? The rich? The powerful? The meek and honest? The strong? The beautiful? The productive? The white? The black? The farmer? The urbanite? The suburbanite?

Furthermore, we will have to make a choice between devoting resources to keeping alive those who are already alive and devoting resources to the sustenance of those who are not yet born. This choice hovers uneasily in our minds as we contemplate the developing countries and note that the economy, despite increased productivity, either remains at a standstill or retrogresses, simply because there are more mouths to feed and more human beings to shelter in the growing metropolitan areas.

We might well ask still another question which we cannot answer: What will happen to the behavior of people if they feel that they have as a near certainty a great life span? What are the ethics and morality of near-immortality in a metropolitan society where the clock of death is arrested? We will have to answer such questions before this century ends.

On a completely different level—the visual form of human settlement—the greatest changes that have taken place in the past century, and that will take place, come from new concepts of space and time.

Modern architecture would have been unthinkable except in an age of speed. The Bauhaus School in Germany and the other 20th century architectural innovators and their followers and corrupters created an architecture of blur: an architecture to be seen at a glance, from a moving vehicle. Mass, size, the relation of the building to its surroundings—these are elements which can be grasped and understood at a fast clip. Ornament and subtle relationships require a pedestrian pace.

The first blur came with the fast railroad train, and the tendency intensified with the automobile and the airplane. (Of course we still have pedestrians, but they are molded by the age in which they live, and they do not see with pedestrian eyes. Even when on foot, they see with motorized eyes, eyes that glance quickly and then glide on to the next object.)

By the age of the airplane, even familiar household items took on a form influenced by aerodynamics. The toaster looks as though it is ready to fly off across the continent; light fixtures, chairs, box cameras, are all streamlined. They are fashioned into an aerodynamic shape.

But what will be the esthetic implication of the next great wave of technology? The space vehicle which is not in air does not have to resist air. It is not smoothed out, but is instead engineered to fit its functions. It is chunky, or bristling with spires, or irregular in shape. The esthetics of the space vehicle is utterly different from the objects of the aerodynamic era.

I suggest that we will see the new technology reflected in our cities. I do not know whether esthetics will take its clue from the new engineered object, or react against it. The architecture of blur may be intensified when in an hour one can travel not from San Francisco to a nearby community, but to outer space. Our cities and the buildings within them may become peripheral, disposable, collapsible at whim.

On the other hand, the new vistas of space and time—and the new engineered shapes—may be so disturbing to us that we will develop elaborate decoration for our urban buildings. We may want to counteract the technology and sharply separate one part of our lives from another. We may try to recapture an earlier scale of buildings and neighborhoods. We may attempt to readorn our buildings, as the architects Yamasaki, Stone, and Rudolph are already beginning to do. Hopefully our new designers will make the metropolis much more exciting visually.

Another matter of importance to our future urban communities is the necessity to stretch the limits of our knowledge about urban affairs.

Paradoxically we (1) know more than we do, and (2) do more than we know. A story is told about the farmer telling the agricultural agent that he already knew how to farm better than he was doing. He was stopped, of course, by capital, by manpower, by his own skills and energy, by apathy and custom. We know much more of what to do in our cities than we are doing. We have been talking about metropolitan organizations, the necessity for planning facilities in relation to each other and to population movements, the need for more competent and better paid personnel, the need for tax reform and new kinds of user charges. We have been talking about these and other subjects for half a century. We even know specific techniques, enabling legislation, and methods of organization that have worked well in one community and could be borrowed by another. But we are stopped for the same reason that the farmer was stopped—and also, of course, because there are certain political advantages to maintaining the status quo.

On the other hand, what superior knowledge we have is often trite and routine. The United States was once scorned for using the basic research and science of Britain and Europe and then applying it. American technology—so it seemed—was parasitic.

That charge is now absurd. Basic research is the hallmark of science in this country. In fact, what has happened is that the solving of simple, day-to-day problems is frequently in disrepute. Good students at our technological schools are rarely interested today in mundane fields such as civil engineering.

It is astonishing how little applied research has been done in fields such as the fishing or textile industries—once keys to our local urban economies. It is the Russians and the Japanese, recognizing that the computer was developed as a search device for submarines, who are using it to search for fish. Similarly, for the most part, it is not the Americans who recognize that the future of textiles does not lie in spinning and weaving but in solid state physics. These and other metropolitan problems such as housing, transportation, and public services, as well as even larger problems such as mortality, will, I hope, become the concern of the new monasteries. Like the old monasteries they must not neglect the ethical and esthetic implications for metropolitan life of these developments. Nor can they ignore the power of Caesar; for whether we like it or not, more and more pressure will build up from mayors, businessmen, and citizen groups to siphon national public moneys to action and research on the problems of metropolitan areas, including the possibilities of expanding technology.

PANEL DISCUSSION

Dr. Werner Z. Hirsch: Before trying to identify some key changes that our rapid advances in science and technology are likely to produce in urban society, I would like to indicate what I consider to be the environment within which these changes will have to take place. The issue can be stated as follows: What are some of the major elements of the American style that will impose limitations upon urban change?

High on the list is the individualistic orientation of the American. It envelops the premise that his economic fate is to be determined by his own acts rather than by those of any political or public bodies. One such aspect is that the American conceives of himself first as individualistic producer and consumer, as economic man, rather than as citizen or member of a community.

A further element of the American style, closely supplementing the first, is ownership of land, home, car, and so forth, even if such ownership is virtually imaginary. Most homes and automobiles are heavily mortgaged to banks which in fact are the major owners of these items. Nevertheless, the feeling of ownership is deep rooted and represents status. The joint effect of these two elements is exhibited in the strong preference for private means of transportation and private housing, both of which have shaped our present cities.

Great mobility fits into the American style. For example, one-fifth of all Americans, on the average, move every year and about every second person moves at least once every 5 years. Technology and a rich endowment in resources has made it possible for us to throw things away easily and obtain new ones, whether they be bottles, watches, furniture, or cars. These factors may have conditioned us to a similar attitude toward homes and neighborhoods. They have resulted in less attachment to home and community, a reluctance to repair and build homes. They have made sound planning most difficult.

I would like to examine a set of technological advances that could greatly affect the metropolitan area without doing violence to the American style. Most circulation within metropolitan areas takes place by private car along surfaced roads. As a result, the private car, which has taken over a horse-and-buggy-age street system, has been the single most important force to shape urban life and form in the United States. It has led to urban sprawl and, at the same time, to traffic congestion. It has polluted our air and turned the city into a noisy madhouse. It has eaten up much valuable real estate so that today about one-third of the land in metropolitan areas is occupied by streets, roads, and highways. Although Americans have a relatively exploitative attitude toward land, few would deny that we have better uses for land than for roads and highways. More important, the acquisition of additional rights-of-way has become so cumbersome, time consuming, and expensive that it often stalls urban progress.

There are basically two major alternatives open. We can travel either on a "high road" or on a "low road." We have all been exposed to the "visionary promoters" of the monorail. Somehow it has remained a vision, and there is no indication that it could actually become a tremendous land saver.

However, recent technological developments raise distinct hopes with regard to underground transportation. They come hand in hand with the rapid increase of urban land prices. These factors together can reach the stage where it becomes economically desirable to divert traffic and parking to underground facilities, for instance, tunnels and subsurface parking. The technological developments have taken place in a number of separate fields. On the one hand, heavy efficient excavation equipment and improved methods of tunneling are being perfected. Powerful and well-controlled sources of energy have been developed to lift a man into space. There is the possibility that these solid propellants can be used efficiently to dig tunnels at great speed. On the other hand, there is also the possibility that an automobile which does not produce exhaust fumes might become economically feasible. This would greatly reduce the extent of ventilation needed for subterranean highways and garages, presently a significant portion of their operating costs.

Let us look into the technological developments that might give us such an automobile which neither emits exhaust fumes nor triggers noise. One of the first horseless carriages was the electrically driven car. George A. Hoffman of the RAND Corp., in an exciting study, points to a number of automotive trends which could mean that the pendulum is swinging back to the electric car. (See ref. 1.) It is quite possible that the battery-operated electric automobile might replace the internal-combustion-engine automobile. Most of the batteries in use today are of the lead-acid type. They are the least expensive on the basis of initial cost per watt-hour delivered, but are also highly inefficient on the basis of weight. Silver-zinc batteries, already in mass production and extensively used in aerospace components, are far more efficient than lead-acid batteries, but are also more costly. The nickel-cadmium battery, already quite popular in cordless appliances, tools, and lanterns, occupies an intermediate position between the lead-acid and silver-zinc batteries.

But perhaps the most exciting innovation is the hydrogen-oxygen battery which is based on a process that was first developed in 1839 by Grove. It was long neglected until F. Bacon used it to develop a fuel cell in 1954 and, since then, industry, the Armed Forces, and NASA have taken an interest in it. For example, a program to develop a lightweight, highly efficient fuel cell is being undertaken under NASA sponsorship for the Apollo spacecraft. The hydrogen-oxygen battery not only promises to be more efficient than any others available—it is capable of an 85-percent efficiency compared to the 10 to 50 percent of most other energy sources—but also appears to be of intermediate cost. This battery is rechargeable thousands of times and does not emit fumes, gases, or noise. It is an exciting prospect for the future.

Hoffman's investigation shows that a compact car which is similar to conventional models in appearance, comfort, performance, top speed, agility, capacity, and price, but powered by an electric battery, appears to be feasible for urban travel. (See ref. 1, p. 15.) Hydrogen-oxygen battery-driven cars with regenerative braking are projected to achieve ranges from 200 to 300 miles between battery refueling, not too unlike the single-tankful range of gasoline-powered cars. The estimated lifetime costs also appear to be comparable to and sometimes lower than those of conventional cars.

There is therefore a distinct possibility that the battery-operated electric automobile can advantageously replace conventional cars for individual urban and suburban travel. A number of forces can enhance its acceptance, and among the most significant is the fact that gasoline and oil prices have been rising faster during the past half century than the price of electricity.

If gasoline passenger cars were to be replaced by electric cars, and tunnel building became more economical, subterranean travel in major portions of metropolitan areas would be possible. Not only would the air pollution and noise problems of metropolitan areas be mitigated, and much land presently used for streets and roads become available for other uses, but the overall density and layout of metropolitan areas could undergo major reshaping. On the one hand, by permitting only through traffic, we could design a subterranean highway system that would facilitate dispersion of urban activities. On the other hand—and this appears a more reasonable approach—a very extensive underground road network could justify locating many of the commercial activities of the city below ground. People could then drive into densely populated areas, park their cars, and walk to work or to shop. Goods could be distributed by piggyback, electricity-powered means of transportation to the particular underground locations. Population densities could be greatly increased and major portions of the existing surface highways and roads could be used for parks, or commercial, industrial, or residential purposes. On the surface, people would move mainly along malls, relatively narrow streets, and moving sidewalks. The development of subterranean urban travel, of course, would have to be integrated with national defense policies, and people's habits and willingness to spend much time away from daylight would have to be considered.

Much of the exploration of the battery-operated automobile and subterranean urban transportation is highly speculative. On somewhat more solid ground, there is another kind of contribution that science and technology can make

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to urban life. I suggest that the rapid increase in research and development is likely to encompass forces that can lead to a blossoming of culture in urban America. Research and development oriented industries have increasingly recognized that they can attract able personnel only to communities that offer fine educational and cultural facilities. For example, when North American Aviation, Inc., was seeking 65,000 acres of land for new facilities, three site-selection criteria were paramount:

(1) Availability of land in large quantities,
(2) Suitability of the terrain for the testing of rockets,
(3) Proximity to higher education centers and cultural and recreational activities required to recruit and maintain a stable group of scientists, engineers, and high-skill-level technicians (ref. 2).

Thus, the cultural and recreational facility aspect even dominated in the selection of a very large land complex that was unlikely to be found in the close proximity of a metropolitan area. In short, then, it is generally recognized that in order to attract R&D industries to their environment, cities must provide increasingly fine educational, recreational, and cultural facilities and programs. The engineer and scientist, in turn, offer the cultural institutions an appreciative clientele which not only financially supports these activities but also often creatively contributes to them. Hand in hand with this goes the general increase in the number of people who are educated and have an interest in cultural life, and who contribute significantly to the cultural life of a society. Even today, as Chadbourne Gilpatric of the Humanities Division of the Rockefeller Foundation recently pointed out, "there are many indications of the spread, variety, and increase of cultural and artistic activity in this country." (See ref. 3, p. 1.) The growth in the number of symphony orchestras has been so phenomenal that Leigh Gerdine, of the Music Department of Washington University, has jokingly remarked, "Were we to project the growth of symphony orchestras in number on the basis of their growth in the last decade and there were no limiting factors, by 1984 the number of orchestras would probably be equal to the population." (See ref. 4, p. 2.)

These two examples clearly do not permit major generalizations. Nevertheless, they suggest some possibly emerging trends. The rapid advance of science and technology seems to offer little hope that it will be overtaken by solid cultural and political achievements. At the same time it appears that science and technology have improved the urbanite's flexibility and variety of choice and will continue to do so, as the result not only of improved means of communication and transportation, but also of new methods to generate power, to dispose of waste, to supply water, and so forth.

It is also quite possible that large-scale research and development will offer an increasingly greater variety of new products that, in turn, will upgrade the aspirations of consumers. Thus, consumption will press hard upon income, with relatively little remaining for taxes and the provision of government services. Hand in hand with this tendency, it appears that there is little in the expanding technology—except for certain communication advances—that is likely to contribute to the solution of such major urban problems as education, juvenile delinquency, and crime. Actually, given the present degree of attention and expenditure, it is more probable that these problems will increase and worsen with expanding technology. (I owe this point to Dr. Norman Townshend-Zellner, who brought it out in a discussion.)

The number of scientists and engineers promises to continue to increase rapidly for many years to come. Since they are a highly mobile group of society, mobility within America will remain high and possibly also increase. Large-scale R&D operations—as recently brought about by the National Aeronautics and Space Administration in a crescent extending from Cape Canaveral, Fla., to Michoud, La., to Houston, Tex., to Los Angeles, Calif.—can lead to exceptionally rapid increase in city sizes and revolutionary changes in their character.

M. J. Moroney not long ago insisted that, "Economic forecasting, like weather forecasting in England, is only valid for the next 6 hours or so. Beyond that it is sheer guesswork." (See ref. 5, p. 324.) He is probably right, and it may be rather foolhardy even to attempt to look into the crystal ball. However, let me suggest that perhaps the most significant implication of the rapid expansion of technology on metropolitan areas is its help in solving some existing problems. However, while unsnarling some that bedevil us now, it will also offer new opportunities so much more exciting and rewarding that we will gladly live with the problems of tomorrow that technology will also undoubtedly provoke.

REFERENCES

1. Hoffman, George A.: Battery-Operated Electric Automobiles. The RAND Corp., p-2712, Mar. 1963.
2. Novik, David: Technological Change and Local Economy. The RAND Corp., p-2568, Mar. 1962, p. 11.
3. Gilpatric, Chadbourne: Cultural Life in Tomorrow's City. Inst. for Urban and Regional Studies, Washington Univ. (St. Louis), IURS/53, 1963.
4. Gerdine, Leigh: More on the Cultural Life of Tomorrow's City. Inst. for Urban and Regional Studies, Washington Univ. (St. Louis), IURS/53a, 1963.
5. Moroney, M. J.: Facts From Figures. Penguin Books (Harmondsworth), 1951.

Dr. Carl F. Stover: I suppose that one of the things that this conference is helping to make clear—as a lot of other conferences have helped make clear in recent years—is that most of us have been wrong in our thinking about technology most of the time. It seems to me that Mr. Meyerson's paper has offered several important guides to our thinking that we would do well to remember.

For example, he has pointed out that technology relates to all of life, and what we do with it can change fundamentally the quality of our human existence. Therefore, he points out—and I agree—that it is well, first, to begin thinking about technology by thinking about man and, second, to make sure that we know what we are doing with that technology before we set out to do it. He reminds us somewhat obliquely of the dangers that are inherent in having the power of technology belonging too much to the technologist, and of the problems of having too much authority over the shape of our common life in the province of too few men. Finally, he identifies the moral issue that is inherent in all of man's uses of technology. The vital question, it seems to me, is not what can be done—because given enough time and the application of enough resources, we can now probably do almost anything—but what is really worth doing.

We probably should have learned long ago from our experience that technology, as well as being helpful in doing something about the problems of urban areas, is also a cause of urban problems. One can argue convincingly, as Lewis Mumford does, that technology has given us our cities and our metropolitan areas. They have developed out of technical necessity. They have developed according to standards and patterns of technical origin. They have been enabled and disabled by technical possibilities. Without a fairly high level of technical capacity now, it would be impossible for these organic aggregations of men and things to exist and to continue to function in their present organized complexities. Since technology in general has given us our cities, it has also in general given us their problems. If cities and metropolitan areas are ugly, and sluggish, and awkward, and unhealthy, and inhospitable, and without character—if they teach bad lessons and prepare citizens poorly—if they fail to foster the good life for man individually or in a community—much of the fault may rightly be found, I think, in the technical ideas and practices that brought them into being.

If cities and metropolitan areas are going to be made better, these ideas and practices need to be reexamined at a fairly fundamental level, in the light of some reasonable judgments of what cities ought to be.

We do not understand technology very well. The classical tradition offers us a view of it that I think might be helpful. Properly understood in the classical tradition, technology is said to be the art of producing predictable changes in men and things in order to create instrumentalities for the good life. This is its promise. In the absence of ideas about the good life to govern it, it seems to me technology becomes abnormative. It becomes an end in itself that can well consume all other ends. This, I think, is the failure of technology and the failure of men in using it.

We also look at our history and see that technology is useful as a cure for urban problems. For some time, the most common response to urban problems has been a call for better technology, both physical and social. The idea is to make technology fulfill its promise by using it to solve the problems it has helped create. That this is ultimately possible is an article of our national faith. It is almost totally unblemished by the fact that the problems that technology creates seem always a jump ahead of the technological correctives. This article of faith provides a substantial part of the foundation for this conference. It is legitimate to ask whether this faith is justified. I think that it will be justified only if we acted properly in relation to technology.

There is no doubt that many of our urban problems require technical solutions. We must use technology to unpollute the air it has helped to pollute; to uncongest the traffic that it has helped to congest; to unsnarl the administrative complexities that it has helped to create. But, in setting about these and other important tasks, I think it is very important to exercise due caution. For while we might, in terms of a particular perception at a particular time, think that a step that we want to take is a good thing—to do something about any one of this vast range of urban problems through technology—we ought also to remember that every technologically based urban problem that we now have started out as a good thing.

The point is that the city has to be seen as an organic whole. In the life of the city, as in the life of man and nature, it is impossible to change just one thing. This is a fundamental lesson of the record of urban growth and of every effort we have made to improve our cities and metropolitan areas. With the increasing power that modern scientific technology provides, I think it is ever more important that we know what we are changing before we start to change it. If we really want to do that, there are some things we have to do. We have to be prepared to get solid information about our situation and about the implications of the change that we want to introduce before we act. Having the information, we must be willing to act on it and not ignore it in terms of some passionate political or personal predilection. This area of municipal research is, I think, an area where there is a great deal of very shabby action on both the part of the researchers and the policymakers.

Probably the most important thing that the space effort has to teach us is how to go about a big job, involving science and technology in achieving a social purpose. It gives us the clear lesson that we need to know what our goals are and what kinds of problems we are going to have to face in achieving those goals. It tells us that these goals and problems must be operationally defined in terms of the total environment in which we are working. It provides us a model for drawing on available knowledge and technical capacity, and for going about systematically developing the necessary additional knowledge and technical capacity. It is a good prototype, in other words, for an orderly, tough-minded attack on a problem and its resolution through the use of man's knowledge and his technical skill.

If we are serious about the urban job, I think we do need to do this same thing. Fall-out, spill-over, or transfer will take place in this way, but it seems to me that you have to start with the problem that needs a solution—not with a technology that needs a use. We would never, I believe, have thought it sensible to try to get to the moon with spin-off from the regular operation of American industry—even though some of the knowledge and some of the technical skills that have been developed in American industry for other purposes have been helpful in getting the space job done. If we had approached the space job with the goodness of heart, the weakness of mind, and the confusion of purpose that characterize most of our efforts to improve urban areas, we would never have gotten off the launching pad.

At the outset, we must decide what cities ought to be. We have to discover how a city can be a good home, fostering good men. This is another reason for caution in approaching the problems of the urban area strictly from the standpoint of technology—for while the city is an engineering system, it is also a human system. In attempting to apply technology to the human system, some of technology's greatest virtues may actually turn out to be its greatest liabilities. The values inherent in technology may not always be the value we want for man—efficiency, order, and rationality as technology projects it. Would a city perfectly ordered by technology be a good home for man?

We ought to recognize, especially when we are thinking about public purposes, that technology in a form of power. As in every case where power is involved in human affairs, the question is how we are going to make it responsible. How can we insure that it serves the common good? If technology is going to serve the common good, we need to discover what the common good is and exercise the judgment and the will to guide technology to those ends. This means a willingness greater than any we have so far demonstrated to guide technology. It is not just a matter of running technology through—it is also a matter of sometimes slowing it, of other times hastening it, sometimes tailoring it and redirecting it—this to avoid creating problems that we are not ready to handle.

By tradition, the pursuit of the common good is the purpose of politics. Thus, if technology is to serve the common good, there must be a political judgment. Here, I think, all of us are inclined to balk, because when we look at politics, we see a bad image. We are reminded of deals, of inefficiency, of wastefulness, and of disorder. One answer to this has been to transform politics into administration. I do not think that this is ultimately the correct answer for a society as dedicated as we are to the importance of the citizen's role in determining not only the directions of his government but also the processes through which his government operates. Thus, a very important consideration which comes about as a result of thinking about technology and its impact on the metropolitan area and upon our national life is how we can somehow restore politics to its proper role as a process whereby the total community can participate in making judgments about the future shape of the common life.

Gen. William H. Draper, Jr.: Dr. Hirsch in his first description of the modern metropolis, or urban center, made it a very unattractive place to live, with all the gasoline fumes and the shambles that modern crowding together of people has brought about. But the fact is that more and more people must like it that way, because they keep coming in from the farms. The statistics show that at the turn of the century when the automobile age started, a little more than 20 million people lived in cities and something over 50 million lived on the farms. In other words, about one out of three lived in the city. Now, there are about 120 million in the cities and about 60 million still outside the city. So the figures are reversed; now two out of three in a very much larger population are in the urban centers. Projections on those lines for as short a period as from now to 1980 indicate that four out of five will be city dwellers; a little further along, it obviously will be five out of six, and eventually the farmer will probably disappear entirely. Therefore, we are not dealing with the problems of technology with respect to the urban centers; we are really dealing—if you look ahead a little way—with technology with respect to the U.S. citizen.

I was a member of the Municipal Manpower Commission, and for about 2 years we tried to study these problems of metropolitan centers. We had a series of circles for about 10 cities in the country, the smallest ones showing the center that was gradually disintegrating and eroding, with the department stores losing their business, and so on. The next ring showed where the tremendous outsurge of population from within and from outside happened in the last 10 years. Then we had a third ring that was a projection of what it would be in the next 10 years. It really made one wonder how the problems of technology, or growth, or building, or roads, or transportation, or supplying electricity, or anything else were going to be solved. However, when you compare the city of today with that of 10, 20, or 30 years ago and note that there are still all of these problems, such as slum areas, overcrowding, and large areas taken up with roads, the outstanding fact, nevertheless, is that the conditions of living for the average individual, and even of those of the poorer class, are much better than they were 10 or 20 years ago.

John J. Gunther: If we can define the metropolitan problems, the new modern technology available, today might permit us some solutions. I do not believe that governmental structure in the local government is a great problem. There are many books written about it, and everyone deplores it all the time. However, in the metropolitan areas in which I have worked, I have seldom observed that it is structure of government that blocks something that really has to be done. The structure of government may not urge along very fast; it does not pull very hard. But once you come up with a problem, such as a water pollution control problem, the legislation follows.

I also do not believe that there is a governmental structure problem in mass transportation. Many mayors, county commissioners, and governors went to Seattle to look at the monorail. I think they all went home wondering what the real difference between it and the Second Avenue or Third Avenue "El" was. Another example is the polio vaccine breakthrough. As soon as it became fairly evident that the Salk vaccine was effective, representatives of local governments, State governments, and the Federal Government met—and it was just a matter of weeks before they knew what they were going to do with it. Occasionally, the biological scientists would hold up action because they were not quite sure the governmental groups should move as fast as they were moving. Again, I do not think that the real problem is the governmental structure.

We do have a problem in education for the acceptance of new technology. For example, we were hoping to make some progress in local government in getting industries interested in using atomic energy for heat. Now everyone is worrying about "thrust" even though some of the research in atomic energy is going on at a very rapid pace. One day we are working very hard to get people to understand peaceful uses of atomic energy and how it can be used in local communities—so that if you want to put a reactor up the river from Detroit, the people won't be afraid that something is going to come down the river and hurt them—then, all of a sudden, we have developed a whole new area of activity in the space field that junior high school children will have to take home so that they and their parents can understand space. We need to have the scientists meet with the children in the grade schools and the high schools, so that they can take some of these messages home to their parents. I think in this way we will get better understanding so that the politicians can move ahead.

I think that the political climate in the country and the political machinery is in much better shape than it was 50 years ago. Many more people are participating in the electoral process. Many more people are understanding municipal management. Many people are involved in their school boards. We have better qualified people running for offices. If sufficient effort is made through educational systems in getting the children and the families to understand technology, our politicians will come up to the task of using this technology in the metropolitan areas.

GENERAL DISCUSSION

Dr. Eugene C. Lee: It strikes me that two of the panelists are in direct contradiction with each other. Dr. Hirsch said, if I understood him correctly, that problems of education, crime, and delinquency—and central problems concerning the health of our democracy and certainly of our urban areas—are likely to worsen in the years ahead. My interpretation of his remarks was that he felt that expanding technology was going to require so much of the intellectual resources that there wouldn't be anybody left to worry about educational problems. I would like Dr. Hirsch to expand his remarks on this point.

On the other hand, Mr. Gunther paints what I think is an overly rosy picture in direct contradiction to the assertion that education, crime, delinquency, and a lot of other problems are worsening. According to Mr. Gunther, we have nothing to worry about.

Dr. Hirsch: It seems to me that technology, except for communication, cannot really help in the fields of education, juvenile delinquency, crime, and so forth. I am optimistic on some of the hardware. I feel we will make great strides there. Therefore, our failures will loom larger. It relates to the point that Mr. Meyerson made that we can't get anybody interested in the field of conventional engineering—civil engineering, for example; it is not exciting. They are interested in space engineering; yet, big problems remain to be solved in conventional engineering.

Mr. Gunther: To clarify my point of view, I say that our local governmental structures are not blocks to using technology in solving our problems in the metropolitan areas. If you can answer the question of how we are going to get better civil engineers, more people to go into education, or more and better sociologists and social workers to work on juvenile delinquency, I think that our political structure in the local community can use these people and can use the technical advances. I say that we do have very real problems, very serious problems—but I do not know of a community, a metropolitan community, that has been unable to move ahead because of its governmental structure. I do not know of a technological breakthrough in water pollution, for example, that has not been used because of some local governmental structure.

Richard Carpenter: In recent months many commentators in California have talked about the rather horrible conditions that we have with air pollution, the urban sprawl, the traffic strangulation, and the other things that are despoiling our countryside. Yet they continue to make prognostications of a population of 50 million people. As previously noted, it appears they are going to continue to come here—these "horrible conditions" notwithstanding.

I believe that the one thing we must do in California is to have a true agricultural zoning. We must preserve our agricultural lands through zoning laws as tough as in our cities. The problem is probably much the same in other states. We can't get owners of farm property very interested in the problem. They want to have the agricultural protection with low assessed valuations but be able to develop the land if the price is right.

Sim Van Der Ryn: Dr. Stover and Mr. Meyerson, how do you feel we can better utilize, on a community level, the kind of Utopian models that, for example, Dr. Hirsch displayed in the transportation field? How can we utilize these to decide, on the community level, what our cities ought to be or can be—or, can we in fact do this?

Mr. Meyerson: I am not sure what Utopian models you mean. I think I can speak for Dr. Hirsch as well as myself—we have not been talking about Utopia. When man tried to be extraordinarily original and think up an animal utterly different from all other animals, he dreamed up the unicorn—a horse with a horn on its head. By and large, the great advances in far thinking, whether in technology or in the social realm, have been not much different from the reality that we have today than the unicorn is from the horse. The tremendous challenge, I think, is to go beyond the unicorn. Here, there have been terrible blinkers on all of us. The scientist or the technologist is a great conservative. Conservatism extends through our disciplines and our professions, and I am sorry.

Dr. Stover: It seems to me that the only thing to do is to make sure people talk about the opportunities and realize that, whether Utopia or not, there are real choices. It seems to me that the other thing to do is to try to encourage more people, through political mechanisms, to display some of the kind of courage that has been talked about by Mr. Meyerson—to come forward and say what the problems and the facts of the situation really are.

I want to give Mr. Gunther an example of a problem that is very difficult to solve, not only because of structures of government—which, as he says, may well be adequate to do the job—but also because of the patterns of political practice which affect what those structures do. This problem is smog in California, which many people in California recognized as a problem and realized that something could be done about it long before we were able to get any political mechanisms in the state moving to do something substantial about it—and all that time, the problem got worse. This affords an example of another point that I tried to make earlier. In the smog story, there were some of the greatest examples of bastardization of the research process to serve a private purpose that we have ever had in the history of research in the United States.

Sherman J. Maisel: Dr. Hirsch made the point that to attract R&D expenditures and aerospace activity to an area, you have to have certain necessary conditions. It seems to me that the number of variables is far more complex than simply having a university and a good climate or things of that sort.

Dr. Hirsch: I think, just as a footnote, that timing is probably important. For example, today every community is making the play for better education, better symphonies, and better museums. Cultural centers are the vogue today. And yet, if a community had done that 3 or 5 years ago—and led the way—then that community really would have a tremendous advantage over any other community in attracting scientists. It is very hard to get a person who writes on the stock market to say something different from anyone else in the business—they all have the same source. I believe the same holds in the creation of a new environment—and the end result could be the same.

Mr. Meyerson: In most R&D investment, you don't have the deterrent you would otherwise have—namely, a time-distance from market. It is very frequently cost plus. This means you are footloose, and when you are footloose, you can play up to the preferences of whatever group is in shorter supply—in recent years, the scientists. Their preferences come to the fore.

Mr. Gunther: Usually, when city representatives prepare presentations inviting industries to come into their area—for example, a textile industry into New England—they say that the wages are low in their area, that there are no members of a union within 50 miles, and that their educational system doesn't cost much to operate. However, if a city is trying to get an IBM headquarters employing many scientists—as Stamford, Connecticut, did—the representatives tell of the advantages of getting to New York and seeing the plays and the museums, of how nice living is in Stamford, and of how good the educational system is.

Mr. Carpenter: Dr. Stover commented that the scientists knew many years in advance that California had an air pollution problem but it took a long time for the politicians to put the machinery together to tackle the problem. This is really a criticism of the scientists. They are the ones who, in my opinion, should be more articulate and should make their problems known more quickly. I know that the first time this matter came to the attention of the California Legislature, it was already a problem of a critical nature. The legislature acted almost immediately. Now it may not have been perfect machinery, and it still isn't perfect machinery; but the politicians did act when the scientists told them there was a problem.

Dr. Stover: I didn't mean to say this was a bifurcated universe in which the scientists knew, and the politicians didn't act. I said there were people who knew; some of the people were politicians who didn't act and some were scientists—and there were people in both camps who denied the problem! It seems to me that even though the legislature did act in 1947, their actions were limited and what ensued from them was certainly limited. One of the problems of our political process is that you can snarl it up so easily—especially if you have a stake in preventing something from happening. There were a lot of people who thought they had a stake in preventing something from being done about the smog problem.

Gen. Draper: I had something to do with the bonds on the Bay Bridge a good many years ago, then was called back 15 years ago in connection with certain improvements that were needed. At that time, a whole transportation system was being considered. There are about 87 different governments around the Bay Area and there is a plan under consideration. Mr. McCaffrey, if there had been a metropolitan government for the Bay Area—which I gather Mr. Gunther doesn't particularly champion—wouldn't the transportation problem of the Bay Area have been solved 10 or 15 years ago?

Stanley E. McCaffrey: It is impossible for me to answer that. There has been a great deal of thought given, over a number of years, to this specific question of transportation—but it has been intensive only in about the last 5 years. In that time, especially during the past year, there has been excellent cooperation in approaching a solution through the constituted governments—that is, through city, county, and district, including rapid transit, and what is known as AC transit, as well as other bodies in the Bay Area. Maybe the job could have been done more simply in another way, but the fact is that the area wasn't ready and has not approved the formation of a district in that way. Specifically, that came up with the proposal of the Golden Gate Authority which, while not a metropolitan government, was a form of metropolitan government dealing with transportation matters. The simple fact is that a plan was proposed 3 or 4 years ago and was not approved by the legislature. Presumably, it didn't have sufficient backing from the people to approve it. Thus, in our democratic society, it was decided that it was not the best thing for the people.

Mr. Carpenter: I think that there is one other side to this too. If there had been a metropolitan government in the Bay Area 20 years ago, the problem would have remained the same—chiefly, one of financing. I think that some of the problems that people feel can be solved by the metropolitan government cannot necessarily be solved by that means. Los Angeles is a rather large city of some 450 square miles. To handle land use plans, the city was placed under a single jurisdiction, with policing powers coequal to that of the State. Look what has happened within that area in the last 20 years. The fact that they had a single local agency of government did not make a difference, and I don't think it would have made a difference here.

SEMINAR F

How Do the Changing Demands for Manpower and Technical Production Affect the Economy of Industry and the Community?

Chairman: KENT D. PURSEL,
Chairman, Alameda County Board of Supervisors

PRESENTATION BY

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HOW DO THE CHANGING DEMANDS FOR MANPOWER AND TECHNICAL PRODUCTION AFFECT THE ECONOMY OF INDUSTRY AND THE COMMUNITY?

Bernard D. Haber

A great deal has been written in the last few years about the technological explosion, but we are still on its fringes. What its impact will be, one can only roughly estimate—and then only by making broad assumptions as to the international situation and as to the domestic political and economic structure.

We are all familiar with the more glowing accounts of the future—a country where leisure is a major occupation and the production of all needs and most luxuries is automatically assured. We may also be aware of less glowing, less optimistic visions—of our accelerating drain on irreplaceable raw materials, of the growing strain on our educational facilities. Rather than pursue this further, I prefer to recommend an excellent, penetrating book, *The Next 100 Years*, by Harrison Brown and others.

Let us see what can fairly certainly be said about present trends. Because of my own orientation I would like to concentrate on the effects of aerospace technology, which in itself is a most comprehensive subject.

"Dutch" Kindelberger, the late Chairman of the Board for North American, used to recall helping Donald Douglas pack his belongings when he moved to California in 1920 to found the Douglas Aircraft Co. All of Douglas' technical data—his stock in trade as an aeronautical engineer—were packed in a single milk carton. Even at that time, the aviation industry was considered to be in the forefront of engineering technology. But it was not a large factor in the national economy, nor even in the economy of most communities in which it existed. The employees were composed chiefly of production workers, who were subject to a fairly rapid turnover because of the movement of contracts from one locality to another. Indeed, there was considerable movement of the companies themselves from one state to another. Consequently little sense of mutual dependence existed between the industry and the local communities.

However, following World War II, and particularly since the early 1950's, mounting technological requirements in the aerospace field have broadened the base of activities of most companies in the industry. Where they were formerly engaged in airframe manufacture, they are now also in missile technology, space exploration, nuclear energy, and other advanced fields. They are no longer called aircraft manufacturers, but aerospace manufacturers, and even this is an inadequate attempt to compass their diverse activities. The projects they are engaged in generally involve limited production; on the other hand, they require considerable scientific research, highly specialized equipment, and virtually custom manufacture.

As a result, the position of the industry—both in the national economy and in various local economies—has undergone a thorough transformation. For the Nation as a whole, defense and space work generally varies from 8 to 10 percent of the gross national product. In many communities the aerospace industry is a leading source of employment, personal income, and business for local suppliers. In San Diego County, for example, the industry provides 25 percent of all employment. The opening of new plants throughout the country has repeated this same situation in other localities.

Perhaps more significant is the upgrading of personnel to include a large percentage of technical and professional people. They represent a wide range of talents in areas once considered far afield from aircraft and missile work—areas such as biology, physiology, astronomy, botany, and mineralogy. Many of these people enrich the educational programs in their localities by part-time teaching, and in other ways stimulate the community to higher cultural and intellectual attainment.

Having established this general scope of discussion, I would like to trace each of these main points in more detail. Although examples will be taken largely from the experience of North American Aviation, they are indicative of the industry as a whole, and will serve well in illustrating the changes that are occurring generally.

Beginning with World War II, the whole pace of technical progress has been accelerated. For example, figure 1 shows the increase in top speed of manned vehicles over the past 60 years. The curve steepens with the advent of jet propulsion in the 1940's, and still more sharply with the use of rocket engines for space flights in the past few years. Within the decade, the Apollo spacecraft will be sent toward the moon at a velocity of more than 25,000 miles per hour.

The question has become not only how fast, but how precise, a speed can be obtained. In the Apollo lunar flight, a variation of 1 foot per second in the injected velocity from earth orbit would cause the intended lunar orbit to be missed by 1,000 miles, unless a correction could be made in flight.

The story is the same in any other measure of performance. During World War II, somebody pointed out that the wing span of the B–29 bomber was greater than the entire distance flown by Orville Wright in his first airplane flight in 1903. As shown in figure 2, the range of our vehicles has, in fact, increased from this puddle jump to distances that are literally out of this world.

Achieving such performance requires an entirely new level of technical prowess. One example is the new demand for precision. Some bearings fit so closely in their housing that they would be stopped by a single puff of cigarette smoke. We have developed means of measuring surface flaws to a depth equaling the diameter of a carbon dioxide molecule.

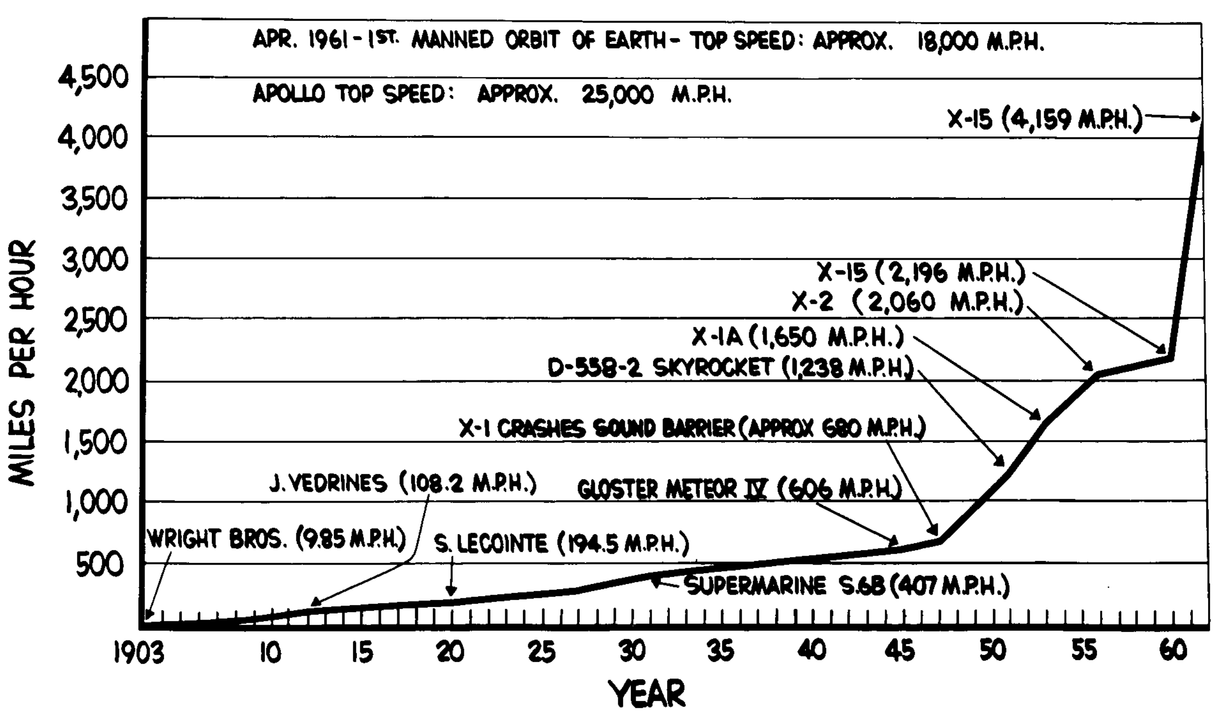

FIGURE 1.—Top speeds of manned aerospace vehicles.

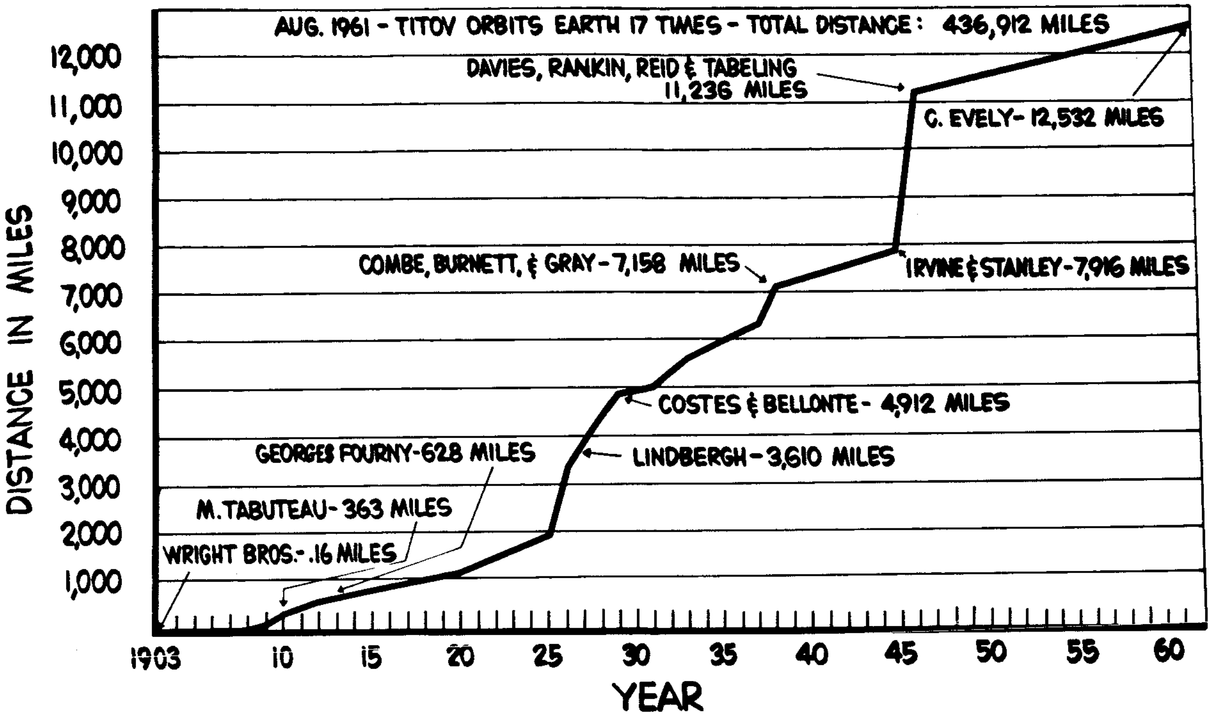

FIGURE 2.—Range of manned aerospace vehicles (nonstop, without refueling).

Because of the intensified performance demands made upon defense and space systems, a premium has necessarily been placed on reliability. The failure of a single part can cause the failure of an entire mission. Therefore, extraordinary effort has been devoted to improving reliability, refining it from a qualitative value to a quantitative measurement. One of these measures is the mean time between failures (MTBF). Figure 3 indicates that for an automobile driven continuously at 50 miles per hour for 1,000 hours, the average mean time between failures is 90 hours. For a modern fighter airplane now in operation, the comparable time is 150 hours. In contrast to these, the Apollo command and service modules are being developed to a reliability measured in terms of 9,700 hours between failures.

This order of reliability is achieved not simply through inspection, but by extraordinary quality-assurance efforts throughout the entire development and manufacturing process. Quality-control personnel work with the manufacturing personnel to assure that standards are met at each step of the way.

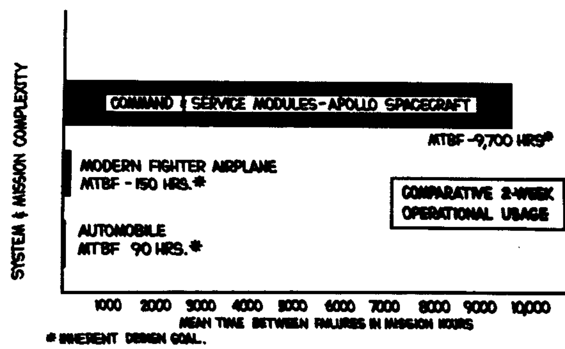

FIGURE 3.—Reliability function (MTBF) for manned vehicles.

In manufacturing the circuitry in various inertial navigation equipment, for example, the connections are soldered by operators who must undergo a 40-hour course to be certified for the work and then must be recertified every 6 months. If an operator produces three defective solders within a 6-month period, he is decertified, put through a refresher course, given a test, and then put on a 30-day trial period before recertification. In the Minuteman guidance system, many components are tested and retested so many times that it costs more to inspect them than to build them.

These performance requirements and operating techniques constitute a major revolution in the aerospace industry. Although hardware is still the end result of practically all our programs, the engineering content has greatly increased. Since many programs require a considerable advance in technology, it is no longer possible to foresee with accuracy the exact end cost of a product. Instead, a very extensive effort must be devoted to the estimation of costs and to improving the accuracy of these estimates. As a result, use of the fixed-price contract that is appropriate for production in quantity declined during the 1950's. Approximately two-thirds of North America's sales, for example, are under contracts of the cost type—that is, cost plus a fixed fee, or cost plus an incentive fee. These contracts provide a fee that is generally smaller than the profit that is possible for an efficient company under fixed price contracts.

It is at this point that "the changing demands for manpower and technical production" begin to affect the economy of industry. One of the accompaniments of the missile and space age has been a general reduction in the profit margin of the aerospace companies, which was already low in comparison with the U.S. manufacturing averages. Even in the short 6-year period after 1956, as shown in figure 4, this trend was pronounced. Average net profit after taxes, as a percentage of sales, dipped from 3.2 in 1956 to 1.8 in 1961, the latest year for which complete figures are available. This is a decline of nearly 44 percent. This trend is not healthy, and it

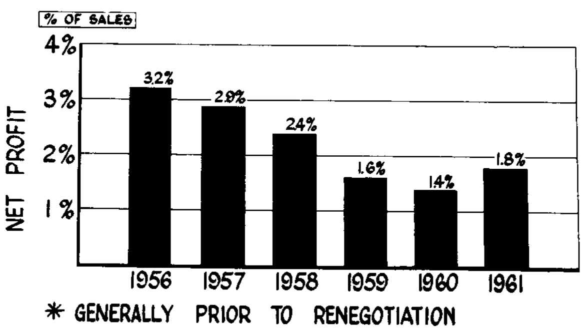

FIGURE 4.—Net average profit of 51 leasing aerospace companies as a percentage of sales (generally prior to renegotiation).

must be reversed if we are to preserve a wholesome and viable industry.

At the same time, demands upon company finances have been increased by requirements for new facilities to keep up with growing technological needs. Some idea of the growth of research and development facilities at North American is given by the following figures.

	1947	*1963*
Floor area, sq ft	82, 000	1, 629, 931
No. of laboratory rooms	30	1, 122

Facilities include wind tunnels (subsonic in 1947 and supersonic in 1963) and the following types of laboratories:

1947

Chemistry	Engine runup
Structures	Fuel
Electrical	Production development
Metallurgical	Aerophysics
Material and process	

1963

Thermoelectrical	Vibration and shock testing
Thermonic	Propulsion system
Instrument calibration	Aerothermal
Physiology and ecology	Aerodynamic
Gas dynamics	Thermodynamic
Astronomical	Electronic and electric
Nucleonics	Computing
Material research	Simulation
Process development	Space science
Production development	Life science
Acoustic	Etc.

The current list, too long to give in full, includes test facilities such as engine firing stands and vacuum chambers, and a science center for basic research.

Providing facilities for these changing requirements demands increasing capital expenditures. Figure 5 shows that this cost, so far as North American is concerned, mounted from less than $6 million in 1953 to an estimated $43 million in 1963. In fact, during the 4 years from 1959 to 1962, the company's capital expenditures were greater than in all its prior years. These heavy commitments naturally add to the cost of doing business and have a decided effect on the company's financial structure. But they are essential in maintaining the company's ability to help meet the technical requirements of the future.

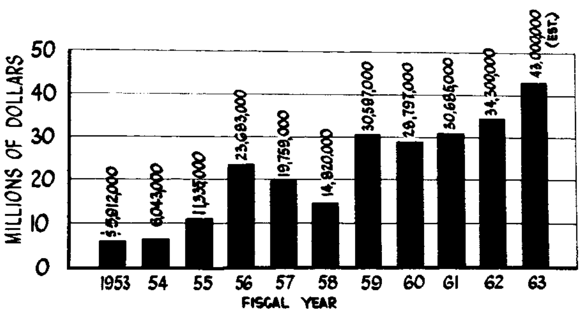

FIGURE 5.—Gross expenditures for plant, property, and equipment by North American Aviation, Inc.

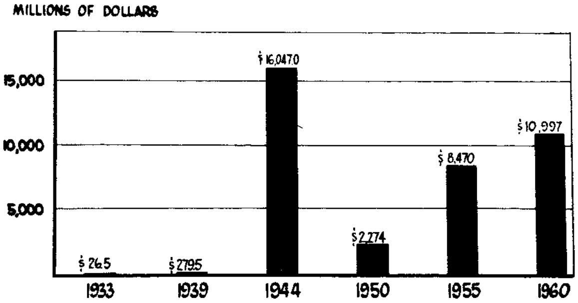

FIGURE 6.—Sales of aerospace industry (principal end-product manufactures only). Data for 1944 and prior years are approximate.

On the other hand, the explosive character of the postwar technological advances has resulted in a much greater variety of aerospace products. Many companies that were known as airplane manufacturers have necessarily entered the fields of missilery, spacecraft, atomic energy, electronics, propulsion, and even marine vehicles. For some of them, including North American, aircraft now constitute less than half of company sales.

In addition, most firms have developed capabilities both as prime contractors and as subcontractors—that is, as developers and producers of entire systems, such as spacecraft, on the one hand, and subsystems or components on the other. This gives them a stake in a much larger variety of programs, including both defense and space programs. (North American, for example, currently has 127 contracts, each with a value of at least $1 million.) Consequently, those companies that have diversified extensively have gained more stability in sales and employment.

In short, the changing demands for technical production have had important economic effects—both good and bad—upon the aerospace industry. At the same time these changes have had a measurable and generally beneficial effect on the economy of the Nation and of communities in which the companies operate. Because of the cold war and the race for space, the industry has become a much larger factor in the national economy. Figure 6 shows the dramatic rise in annual sales by the aerospace industry, from $26.5 million in 1933 to $16 billion at the height of the war, followed by another sharp rise between 1950 and 1960.

It is important to note that such figures represent the output, not of a few, but of many thousands of companies. A large part of the work of any prime contractor is subcontracted to other companies which, in turn, call upon the specialized skills of other suppliers. In most large programs there is a succession of these supplier levels that is directly traceable to the third and fourth tiers, and even farther. For some of North American's larger programs for instance, estimates of the total number of companies involved have ranged from 10,000 to 20,000. Many of these are new companies formed to enter fields where there was room for more competition. The significance is that, contrary to some opinions, the age of individual initiative is not dead. The man with a new idea can still start a successful business. The community is benefited by this addition to its income, and the economy is refreshed by this injection of new energy.

It should be acknowledged that undue dependence on the defense and space industry can make a community vulnerable to dislocations resulting from contract cancellations. In addition, when a new plant is established, a severe impact on community services frequently results from the influx of a relatively large number of people to the community. This situation may be further aggravated by the fact that, as the laws of taxation apply in many states, the state and local taxes paid by a government contractor will be less than the taxes paid by a company which is not primarily a government supplier. However, I know of no community which would reject aerospace business on these grounds.

The fact is that the establishment of a new aerospace plant has a very salutary effect on a community, and in many instances has virtually revolutionized the local economy. One noteworthy example lies in San Mateo and Santa Clara Counties of California. Chiefly because of the location of aerospace plants there since the war, the San Francisco peninsula has developed rapidly; home construction has boomed and whole new shopping centers have appeared. Where there were once separate communities, there is now a continuous suburban area down the length of the peninsula. The population of Santa Clara County alone is now greater than that of San Francisco.

Let me give a more specific example from my own company's experience. In 1956 we opened a rocket engine plant in Neosho, Mo., which has a population of 7,450. Our employment there has ranged between 1,000 and 1,300 persons, representing approximately one-half the manufacturing employment in the county. For the last fiscal year, our Neosho payroll was $8.7 million, and our purchases from suppliers totaled more than $5 million. Our location caused a building boom in the supply of new homes for employees, which, in turn, greatly improved the assessed valuation of the city and county. Because of the demand for technical education, nearby colleges shifted their emphasis from agricultural courses to a broad range of subjects. Many night courses were established and are well attended.

Neosho is but one example of a community changed by aerospace activity. There, as elsewhere, the company takes its place as a responsible citizen of the community, contributing to charitable causes and encouraging its employees to do so through payroll deductions. The company establishes its own employee recreation facilities, and encourages the establishment of employee hobby and sports clubs. In these and other ways it adds to the cultural and social life, as well as to the economic prosperity, of the community.

In cooperation with government policy, the aerospace industry has also been able to assist the economy in areas requiring special stimulation. Particular attention has been devoted to directing procurement toward small business in order to encourage this vital element in our competitive society. Considerable effort is being made to find or develop suppliers in areas of economic need. Many of the companies feel that because of the large amounts of public funds used in their business, they have a public responsibility to help bolster soft spots in the national economy, if this can be done without compromising technical merit. This may be carried to the point of establishing a branch plant in such an area. North America, for example, was unable to find suppliers with suitable skills in West Virginia, so we established our own plant there and have provided employment to several hundred people.

Still further, I think it is fair to say that the aerospace industry has been in the forefront of the movement to provide equal employment opportunities to all Americans, regardless of race or creed. My own company has, for instance, several thousand Negroes employed at various levels of responsibility. More than 600 have salaried positions, including 143 supervisors. We have 105 Negro engineers specializing in the aeronautical, electrical, and mechanical fields. For example, one of our Negro employees, who started as a janitor in 1942, is today a senior electrical engineer who investigates, analyzes, and solves electrical problems relative to fusion and resistance welding. Another example is a Negro, hired in 1948 as janitor, who progressed through several manually skilled and laboratory analytical jobs into the field of health, physics, and safety. In his spare time, he continued his education at Long Beach City College and the University of California at Los Angeles. He is today Chief of Health and Safety at our Atomics International Division, supervising a group of 45 employees.

This brings me to what is perhaps the most important economic and sociological effect of our changing technology—the rising level of employee skills and education. The growing technical content of our products has been accompanied by a considerable growth in the production of our employees in engineering departments, as compared with production departments. Figure 7 shows the numerical increase of employees in the engineering departments of North American from 1946 to the present. I might add that the percentage of engineering employees to total employees increased from less than 4 percent during World War II to nearly 27 percent today. Figure 8 shows the changing situation in a typical aerospace firm, as given in a recent issue of a management magazine. In 1954 the managerial and all other professional personnel constituted 38 percent of total employment. According to projections, the percentage will be 61 in 1965 and 70 in 1970.

This trend toward more highly qualified personnel can be measured by other North American statistics. As shown in figure 9, the

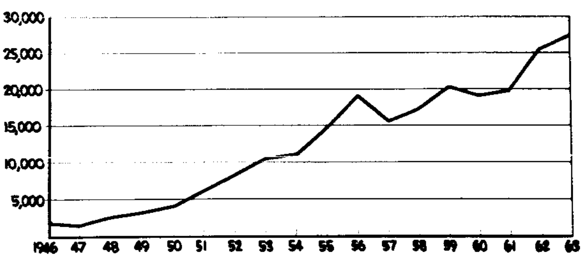

FIGURE 7.—Research, development, engineering, and engineering support personnel of North American Aviation, Inc. Data as of February 23, 1963.

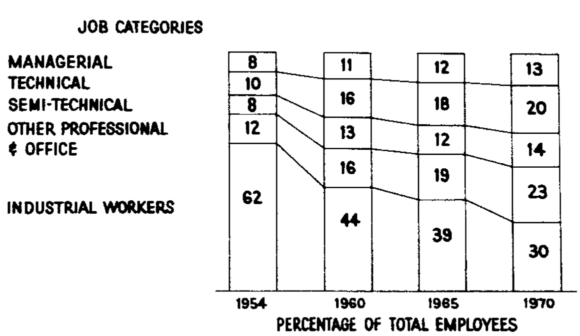

FIGURE 8.—Employment requirements in typical aerospace company.

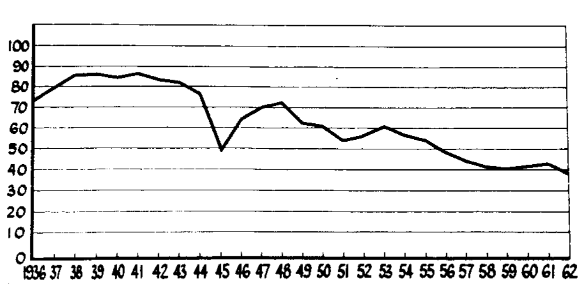

FIGURE 9.—Hourly paid employees as a percentage of total employees of North American Aviation, Inc. (as of December 31 of each year).

percentage of hourly paid employees—as distinct from weekly and salaried employees—has dropped from 73.4 percent in 1936 to 42.8 percent at the end of 1961.

Another yardstick is the number and types of college degrees. The following lists indicate the diversification in types of degrees at North American:

Typical degrees in 1943

Mechanical engineering	Chemical engineering
Electrical engineering	Physics
Aeronautical engineering	Metallurgy
Civil engineering	

Typical degrees in 1963 (more than 175 different disciplines)

Actuarial science	Metallurgy
Anthropology	Mining engineering
Architecture	Nuclear physics
Astronomy	Nuclear engineering
Astrophysics	Optics
Bacteriology	Osteopathy
Banking and finance	Phosphate industry science
Biochemistry	Photogrammetry
Ceramics	Physical chemistry
Electronic engineering	Pomology
Exfoliative cytology	Psychology
Gemology	Sociology
Geodesy	Soil science
Geophysics	Tool engineering
Library science	Traffic management
Marine engineering	Zoology
Medicine	Etc.
Meteorology	
Microbiology	

Twenty years ago, nearly all our engineers had degrees in aeronautical, civil, electrical, and mechanical engineering. Today, North American employees have degrees representing more than 175 different college majors. Among North American's 36,000 salaried and advanced technical people, there are more than 18,000 degrees. These include 15,583 bachelor's degrees, 2,440 master's degrees, and 427 doctorates.

It must be emphasized that this upgrading of personnel skills is not accomplished simply by hiring new and more skilled employees. The companies have often adopted programs to improve the talents and training of existing employees. The three different educational programs conducted by North American, for approved courses at approved schools, can be outlined as follows:

1. Educational reimbursement program—
   - Reimburses two-thirds of tuition and fees at completion of course,
   - Reimburses balance on award of degree,
   - Participation in calendar 1962:
     - 10,179 courses completed by 7,469 applicants,
     - 153 bachelor's degrees awarded,
     - 79 master's degrees awarded,
     - 6 doctorates awarded.
2. Prepaid advanced-degree work-study program—
   - Pays full tuition and fees for selected personnel,
   - Participation in academic 1962–63:
     - 339 employees working on master's degrees,
     - 70 employees working on doctorates.
3. Educational fellowship program—
   - For advanced-degree studies in science, engineering and mathematics,
   - Pays full tuition and fees, allowances for books and supplies, and income stipends,
   - Gives supplemental grants for educational institutions,
   - Participation in academic 1962–63:
     - 14 candidates for master's degrees,
     - 18 candidates for doctorates.

The oldest and most comprehensive of these is the educational reimbursement program, in which employees are compensated for two-thirds of the costs in taking courses designed to increase their skills. We recently instituted the two additional education programs for graduate work, in which full tuition, and in a number of cases living expenses, are given to candidates for advanced degrees. In addition, many companies, including North American, make direct grants to schools, conduct scholarship programs for children of employees, and in other ways help to support higher education.

Nor is this upgrading of personnel confined to supervisory and technical people. Many of those in North American's educational programs are hourly employees. As a further instance, we have been conducting for a number of years a program to train blue-collar workers for higher positions. In 1961 nearly 24,000 employees were taking training under this program. Partly as a result of this effort, 2,423 blue-collar workers were transferred to white-collar jobs in 1960 and 1961 in our Los Angeles area divisions alone.

This trend toward more educated personnel is having a strong economic and sociological impact on the communities in which aerospace companies are located. Foremost is the increased purchasing power. In North America's case, as shown in figure 10, average annual pay per employee has risen from $1,468 in 1937 to $7,852 in 1962. Even allowing for inflation, this constitutes a substantial increase in expendable income. In addition, the types of goods in demand have naturally been affected. Savings accounts have increased, with consequent growth in the lending funds available for new enterprises and other activities of benefit to the community. Improved property values, tax revenues, and charitable contributions are just a few of the additional advantages to the community from this caliber of resident.

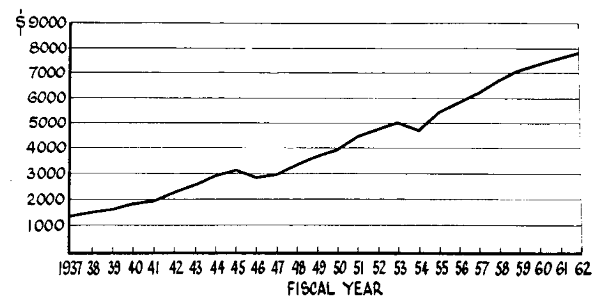

FIGURE 10.—Average annual pay per employee of North American Aviation, Inc.

Still another effect has been the tendency for people of higher education to take a more vital interest in community affairs—to support local activities for civic betterment and to take a larger part in local government. Many of North American's employees, for example, have been elected to public office, such as city councils and school boards. Many share their knowledge and talents with the community by serving on college faculties.

In other words, a high level of employee education makes for a more enlightened, informed, and dynamic electorate. It gives a most encouraging answer to Jefferson's maxim that democracy without education is unworkable.

A still broader effect is the motivation that these people bring to their work. Those who have had the initiative to improve their training and education are those with energy, ambition, and a willingness to assume responsibility. In an industry which rewards efficiency, they can see around them opportunities for further self-advancement. They are stimulated to put forth not only the effort that is required of them but an added measure as well.

The result is that the nation is benefited in at least two ways. The first is a quantitative increment of effort. For example, in 1959 North American began keeping track of the hours worked by its salaried employees, partly to determine, in cooperation with the Air Force, whether they were actually putting in all the hours they were being paid for. It turned out that they were devoting more time, rather than less. In 1962 these net uncompensated overtime hours totaled more than 1.7 million. Translated into a total dollar amount based on average salaries, the Government may be said to have received in that year nearly $8.7 million more than its money's worth.

Yet a more important bonus is a qualitative value, in the form of the original ideas, the creative energy, and the competitive drive generated by these people. Allied with this is a sense of responsibility—an interest in the success of the program and an identification with the fortunes of the company. These are unmeasurable benefits, but they are the real fuel on which our system operates. They constitute the vital difference between free enterprise and the Communist system. In the end, I firmly believe they will provide the critical measure of superiority by which the one society will survive the other.

PANEL DISCUSSION

W. S. Evans: I was impressed again with the point brought out as to the effect of the aerospace industry on the community. Of course, we all know the effect when a contract is cut back. This makes for a very unstable situation. Is there any further development along this line—any comments as to further enlightenment or solution? Is this as unstable as it might seem to be?

Dr. Ivan A. Getting: This has been a very deep concern with me. Some of you may have read Mr. Rubel's speech not long ago, in which he pointed out that 75 percent of the total R&D dollars spent in the United States comes directly from the Federal Government. He also pointed out that last year, and for a number of years in the past, the average increase of total R&D has been 10 percent per year. There has been adequate manpower to support this. But last year the amount spent by private industry on R&D went down in absolute dollars.

This can be a very serious situation, obviously, if there is any major cutback in any aspect of Federal spending. In the commercial electronics and hardware business, a million dollars of sales will support one or two engineers; whereas in the Government business today, in space and missiles, the same amount of sales will support about 10 times that many engineers. I am just supporting Mr. Haber's very clear data on the change in the way dollars are being spent. Now, the clear implication of this is that, if international tensions should lessen appreciably, with a resulting decrease in the demand on the part of Congress for prestige items—whether in so-called peaceful space or civilian space or in military equipment—there would be a terrific amount of unemployment. The whole situation would become very unstable. Therefore, I think this is one of the major problems which requires effort toward a solution.

Louis O. Kelso: As a matter of fact, the picture is considerably more unstable than Dr. Getting suggests. I am impressed with Mr. Haber's comments as to the effect of the aerospace industry, but he did not satisfy me that an industry of equal size—for example, one that was engaged in the production of consumable goods and services or engaged in the job of industrializing the developing economy—would not do everything that an aerospace industry would do for its community. In addition, it might do a great deal more for mankind.

We cannot turn our backs on this problem The President, in his economic report this year, pointed out that some $40 billion of unused industrial capacity existed in the United States in 1962. The Conference on Economic Progress, a research organization in Washington, has added to this by pointing out that there are some 77 million people in the United States that live in poverty or in privation.

We have an affluent society, certainly, by comparison with all past societies and with most present societies. But the label of affluence applies to about 7 percent of the economy, and some 77 million Americans are getting very little out of technology. That is not really the beginning of the story either—80 percent of the world's population may be said to derive almost nothing from technology today. As C. P. Snow, the distinguished British scientist, has said, they live "brutish lives, indistinguishable from those of man before the industrial revolution."

The question of the insecurity of our present posture cannot be weighed without taking into consideration the fact that we are devoting enormous talents, a great amount of time, great resources, great know-how, and great attention to space exploration when, in fact, we are defaulting on our obligation with respect to half or more of our own population and at least 80 percent of the world's population.

I think these people will call us to account someday by asking, How can you put this kind of money into space when we are starving to death—when your life span expectancy is two and a half times ours? How can you spend your wealth that way?

These things are behind the insecurity. A really affluent society can afford a massive space effort; a partially affluent society may not be able to afford a space industry. The one thing that our political leaders impress on us is that the rest of the world knows that it is easy to produce wealth. The real problem is how to make it available to mankind. C. P. Snow again made this point in his little book on the two cultures. He said: "The secret is out, and it's been noticed by all the wrong people, namely, the people who are poor and starving in the developing economies."

If we are to be able to address ourselves to the exploration of space, we had better solve this distributive problem now. The economists, the political scientists, the lawyers, the financiers, and the bankers are doing a poor job. They are not using the objective intelligence that science uses in analyzing the problems before them. The very function of technology is a mystery to most of mankind. By and large, labor leaders, heads of industry, and leaders of government say that the development of new capital instruments to produce wealth "increases the productivity of labor." This is a kind of mysticism that science would not tolerate, but it passes for currency in the social sciences.

Technology, I think, is a process by which man is harnessing nature and making nature work for him. It is shifting the burden of production off the back of labor and onto the machine. But we talk about billions and billions in new capital formation and not one new capital owner. In a preindustrial society, every man owned labor. God made him a producer; he was built that way. But in an industrial society, labor is accounting for less and less—and, as the president of a company engaged in automation recently said, "In another decade it will account for only a fraction of the total wealth produced." My own estimate is that it accounts for less than 10 percent of it today, although economic statistics do not reflect that. We measure input by out-take, which is something else that no scientist would tolerate.

I suggest that the scientists and the business executives plunge into the social sciences, analyze them, and throw out some of the ancient illusions. I believe that the whole economic fabric, and the thinking that underlies the fabric, is based on the theory that there is only one factor of production. Capital accumulation and the financial aspects of it receive a good deal of lip service, but in general, capital is treated as something that mystically enhances the productivity of labor.

If an improvement is made in a machine and it then requires only 2 operators rather than the 10 it previously required, the social scientists say the productivity of labor has gone up. Apparently they are even saying that the productivity of the men who were displaced has gone up, too, although they are among the unemployed. We need to attack the social sciences and bring them up to date. Then we can afford a massive space effort. If we all are wealthy, we can afford to spend our wealth in ways that advance the knowledge of mankind for the sheer joy of knowing. There may not be anything in space we want, but we can at least afford to find out. But we had better not turn our backs on the people right here in the course of doing it.

Dr. Karl Wolf: I think the space effort is really a blessing in disguise, and so are many of the defense expenditures. It is unfortunately true—if we look back—that much of the progress of humanity has been accomplished by things we really could not afford, such as wars, for example, in which great efforts went into research and development and brought forth new technology. Mr. Haber very eloquently pointed out this blessing in disguise, and also the impact that it has on a free society. He mentioned that many new companies are growing up and that if people are trained, they have a better chance to express their individual creativity and to contribute to the commercial field.

I would like to address some questions to Mr. Kelso. Do you have any suggestions as to how to establish a balance among the technological manpower in a society? What share should be, say, hand labor? What share should be intellectual labor? And among the latter, who should be engineers, scientists, physicists, social scientists, and so on?

Mr. Kelso: I do not think it is a quantitative problem. The problem exists well enough. We must have a free society, and the number must adjust itself. Man is a creative animal; where he sees need he instinctively rushes in to fill the need.

If I were to point out a single place where one could begin to correct this most difficult problem, it would be in the world of finance. The world of finance is built up in a system that has arisen out of tradition—it is unexamined, unscrutinized. Yet it holds itself to be a mystique which we must not even ask about. Most people accept this; most people are afraid to even query financial institutions.

In our systems of finance, new capital formation is built on savings. Such techniques give the existing owners or possessors of capital an exclusive franchise to acquire and own newly formed capital. Thus, by simple definition, the system is not designed to broaden the proprietary base, or to have more and more men participating in production as owners of capital, or to have more and more families supplementing their labor income with capital income, which would enable us to build the power to consume as we build the industrial power to produce. This is purely a structural defect. We tolerate it because it suits the interests of certain people. In failing to recognize that capital is the producer of wealth, that it produces wealth in exactly the same sense as labor, we fail to insist that, just as the right to work was a heritage of man in a preindustrial society, so too the right to own capital privately should be a heritage of man—increasing numbers of men—in an industrial society. The institutions of finance should be reformed to allow the exercise of this right; I think it is very easy to do. I have written a book in which I have blueprinted one technique, but I do not think it is the only technique.

If I were to put my finger on one single place to start reformation, to upgrade all the social sciences, it would be on the world of finance.

Dr. Getting: It is my impression that, as a country, we can produce more food than we can use, more clothing than we can use, more fuel than we can use, and more mechanisms of transportation than we can use. Undoubtedly distribution can be improved. I am not in the least concerned about broadening the ownership base in this country. Practically everyone at the present time has savings accounts, stocks, or other such things, even at the laboring level. I think these things are all good. But over and above all this, we have a surplus of skills and ability which somehow has to be used or we will have unemployment and a worse distribution situation.

I suggested that perhaps the space effort was a good way to use up this surplus ability and furnish employment of a high intellectual level, which brings about more education and higher standards of the type Mr. Haber has suggested. We could, instead of going to the moon, make sure everybody has two cars instead of one, and two outboard engines instead of one, and six chickens in the pot every night—even though we couldn't eat them. We are an affluent society, and it is this affluence that makes it possible for us to do the things Mr. Haber's company is doing.

The danger is that it is not necessarily stable in the long run. How do we get stability in an affluent society?

Earl D. Johnson: Mr. Haber said that he thought his figures would probably apply to the aerospace industry as a whole. I sent an advance copy of his paper to our organization, General Dynamics, where employment has been as high as 110,000. It is about 85,000 at present. Basically, the figures for our company agree with Mr. Haber's, after the noncomparable activities are eliminated.

As Mr. Haber pointed out, the change in composition of the work force has resulted in a steady progression toward a higher and higher ratio of scientific and engineering specialists vis-a-vis production and unskilled workers. In these companies, the unskilled worker and even the production worker is falling into the same category as the agrarian worker in our national economy. This situation is a direct reflection of the increased emphasis on advanced technologies encompassing the entire spectrum of scientific and engineering disciplines. It points up the individual nature and limited production runs of even those items of hardware covered by the largest volume of defense contracts.

Is it possible to deduce from the experience of aerospace companies that this generalization will apply to the work force in the civilian economy as the techniques and knowledge from the aerospace industries sift into the production and complex type of operation in the more advanced companies serving the civilian economy? It seems to me that this is going to happen, and when it happens, the result will not be unemployment of what was in the past considered labor—that is, the lower level of worker—but a cyclical impact in employment upon the men of the highest intelligence. This is something that will produce a real reaction, because these men are intelligent; they know how to write; they know how to speak; they know the news media; they know the forums they can appear before and get action. It seems to me that these cyclical fluctuations, affecting the brightest minds, are going to have a real impact upon our society and upon our urban life.

Dr. Louis Winnick: Both Mr. Haber and I have been focused fairly closely on the aerospace industries, whereas Dr. Gordon, in his paper, took a larger spectrum for his subject matter. In Dr. Gordon's statistics, the unemployment rate in the higher professional and technological skills was almost invisible.

I had a little trouble understanding the word "cyclical" as used by Mr. Johnson. I think his concern is "instability." Consider the aerospace industry, which is so bound to government contract work, which in turn is bound to political decisions and to Congressional budget-making. Suppose that the faucet were turned on and off at some unpredictable and irregular rate. The unemployment curve would then fluctuate, showing an effect on employment in the higher engineering ranks as well as on the unskilled workers. I think this is the situation we are considering.

It is my impression—and I think there is considerable data to back it up—that there is a tremendous shortage, in the true economic sense, of all the skills we are talking about. There are enormous numbers of unfilled jobs which cannot compete with the engineering salaries being paid by cost-plus contracts. For example, there are several thousand unfilled engineering jobs in the Government. There is no highway department that can fill its engineering requirements; there is no mechanical department in the Government service that can fill its engineering requirements. This is also true for architects. It is almost impossible for FHA to hire the quality of architects it could get in the thirties.

Although I agree that there would be considerable economic hardship and geographical movement of people, the adjustment would not be in terms of substantial unemployment rates among the highly skilled technologists. They might have to adjust to smaller salaries than they have been used to and they might have to move around a good deal, but I don't think the picture is quite as black as Mr. Johnson pictures it.

Mr. Johnson: I do not mean it is black. I mean it is a new element introduced into society which has not yet been put into focus. I agree that there is a shortage in certain types of activities, but consider the way in which huge government contracts are being let. What takes place? In sequence, there are the theoretical concept, the feasibility studies, the design studies, the prototype and testing, and the production. These contracts may run, in some cases, 10 or 15 years.

As an example, our company has a contract that will require, in the beginning, a tremendous number of the highest quality engineers and scientists across the whole spectrum of disciplines. Within 2 or 3 years that phase will be past, and then the production phase may run 4 or 5 years more. How does one keep these men employed in the meantime, during the 4 or 5 years? The point is that the research and engineering must finally come to an end. There comes a time when research dollars must be interpreted in terms of the practical effect, whether it is a vehicle or a venture. The ratio between the dollars required for the follow-up work and those required for the initial research work is astronomical, especially when it is realized that about $10 billion per year is being put into research in this country.

Robert J. Lacklen: NASA has, naturally, been accused of having a very great impact on the manpower pool in the country, and so we have conducted some studies to determine what would be the effect of sudden elimination of the space program. For example, NASA now has, working as employees, a little over 9,000 scientists and engineers. According to the best information we can get, our contractors are currently employing another 33,000 or 34,000. This means that there are approximately 42,000 engineers and scientists working on the space program. These figures are based on actual expenditures, which lag behind obligations and appropriations.

We estimate that the scientist and engineer pool now contains about a million and a half persons. Therefore, even if NASA continues to grow to some extent, and levels off at a budget of around $6 billion per year, it will never, in-house and under its contracts, use up more than 7 percent of the scientists and engineers of the country. Thus, the space program does not appear to have tremendous impact on direct science and engineering manpower.

It has been said that over two-thirds of the research and development in the country is being financed by the government. But consider the fact that of the entire scientist and engineer pool, only 36 percent are at present engaged in R&D work—and NASA programs occupy only about a quarter or less of that 36 percent. It is a pretty big pool.

It is true that as the years go by, an increasing percentage of our work force will be composed of scientists and engineers, and this trend seems to be very strong. The colleges may catch up with us; or they may not. Some people are worried about the fact that engineering enrollments are not keeping up with the growth and need. I, for one, am not very much worried about unemployment among scientists and engineers. In 1948 there were many predictions of a large oversupply of engineers. Then the Korean action came along, and we have been desperate for technical people ever since. Thus, I do not think the space program—at least the space program as it is now set up—even with all the contracts, is likely to upset the big population of scientists and engineers to any great extent.

Dr. Kenneth S. Pitzer: I would like to underline that last point. There are still many demands for highly trained people, in spite of their great numbers. Many college faculties, for example, have unfilled positions or positions filled at much lower levels of education and training than the college would like. In many places the economy could take up additional highly skilled people if they became available. As has been mentioned before, the salaries might be lower and they might be in a different location—but nonetheless, the opportunities are there.

The great problem—and this is becoming more and more an urban problem instead of a rural problem because the population on the farm is small but the low-skilled or unskilled population in the city still is large—is the excess of unskilled workers or workers of relatively low skill that need to be trained to some higher skill in order to fill an existing need. This, of course, has been widely recognized, but it needs to be underlined at this point. There are large numbers of people involved in this problem, and cyclical situations, such as the end of a production run, will add to the problem of placing people in new activities.

Mr. Johnson: One of the impacts of these developing technologies will be the continued need for expansion of educational institutions and activities at all levels. Because of the way education is financed, this means more money from the taxpayer. Governor Brown has said he wants to upgrade the worker, but he is running into resistance. Who is going to do it? Is it going to be done at government expense at the local level, or at the state level, or at the Federal level? Or will it be done by the corporation with in-house programs such as Mr. Haber mentioned? This is one place where the impact of these new technologies is having the greatest effect on the individual and on the urban community.

Robert S. Ash: You talk about labor people. I am the only one at this conference. But I am not concerned with the scientists and engineers, because they do not belong to our unions. It might be well, Mr. Johnson, if there were a big surge of unemployment among the scientists and engineers and high technicians, because if it is true that they are able to get to the press media and able to speak, maybe they can do a better job of talking to Congress and the State legislature. If they do that, with their ability, they may be called worse radicals and Socialists than we have been called.

I am not concerned with this expansion of technology, with the expansion of the need for scientists and engineers to build bigger and more computers and so on. I am concerned with the person who is replaced—the craftsman, the unskilled person. In particular, I feel sorrier for the unskilled person than I do for the craftsman or the person with a mechanical trade who is replaced. I had hoped that someone would come up with an idea for solving the problem.

As for training and retraining these people, it has to be done before they are replaced—and it cannot be done overnight. A company may bring in, almost overnight, new equipment, machinery, and computers—and then give the workers 2 weeks' notice or, in some instances, several months' severance pay. You cannot expect those people to be retrained because they have no place to train. They have no job to go to in many instances. We have had, in the past few months, two or three strikes and threats of many more over this matter of automation—simply because industry and Government have not tried to train the people ahead of the changes. Maybe it is impossible; I do not know.

The other thing that concerns me is: If we do retrain them, where are they going to work? In a recent cartoon, a man was sitting before a great big computer, watching the buttons. Back of him his boss was holding a smaller computer and saying, "Move over. You've got another technician, another computer to watch the lights." I think eventually it will benefit all of us, but for the next few years I foresee no benefit to the man who will be out of work.

My question is: What is industry doing to retrain in advance the production worker, the skilled mechanics, the people who are going to be replaced by these machines?

Mr. Locklen: While the need for labor is going down, the need for technicians is going up very rapidly. In fact, we have a saying that we are shorter of technicians than we are of scientists. A good technician is harder to find than a scientist. These are people who primarily came out of the trades and crafts. This is an area of retraining that is greatly needed, and we are trying to do what we can.

Mr. Johnson: A distinction must be made between those things that can be done in an orderly process and those things that must be done under a crash program. When Douglas received the cancellation of the Skybolt, they must have had to move without any regard for retraining time and relocation of people except for a very limited few. They were caught. When the Navaho was canceled, North American had around 15,000 people at Downey and about 10,000 were discharged in something like 60 days. There is no chance to do anything under such circumstances.

However, when we go from one program to another on an orderly basis, we can accomplish much. For example, in our company at Pomona, we have had this opportunity. We have established in-house classes and we have made arrangements with outside institutions to conduct this training. We have introduced training aids. Television has been a tremendous help to us in transfering skills. We have done things with training aids which seemed impossible even as recently as 4 or 5 years ago.

But, again, the change that is taking place under the impact of these burgeoning technologies has reached such a pace that it has gone out of the evolutionary and into the revolutionary stage—and that is where the rigidity set in. As a matter of fact, the social system, the governmental organization, business organizations, and even the educational institutions have become as rigid as many of the government institutions.

Mr. Ash: I think you miss the point of my question. I am not necessarily concerned with what is happening to the space industry. I am concerned with what is happening to other industries as a result of byproducts from space-industry developments. If my son wanted to be a machinist or mechanic, about the only trade I would pick for him would be a "body and fender man" in an automobile shop, because as long as freeways are built, there will be smashed fenders. I do not think they will ever make a car that will not break up, and he would have a job from here on out. But I am concerned with the byproducts of what you are developing in NASA and the space industry that are going to be used by other industries.

Mr. Kelso: The question, I take it, is: What is the effect of technology, more accelerated technology, coming out of the space program? The picture is probably darker than Mr. Ash has painted it. The President's first report under the Manpower Act of 1962 has just been released, and in it he points out that between 1947 and 1957, the economy generated 700,000 jobs a year. From 1957 to 1962, the rate dropped to less than 175,000. But that is only one side of it. The number of new entrants in the labor force is growing each year and will grow each year for the next decade—by 13 million, according to this manpower report, during the 1960's and by another 7 million between 1970 and 1975.

The problem of labor unions is, or should be, much bigger than just the problem of retraining their own members. They certainly should be concerned about that, but unions should also be concerned about those who have no other means of participating in the production of wealth and who are going to be part of the labor force and will not get jobs in the future. The general figure of unemployment today is about 6 percent, but among teenage children it is about 20 percent. Among teenage Negro children it is about 25 percent. And this is in spite of all of the efforts that have been made to cover up the effects of unemployment: enormous feather-bedding in some instances, and all kinds of industrial attempts—out of good will, without any question—to hold people in industry until they die off, though they will not be replaced. Someone mentioned Erma. It will be a long time before any bank clerks are hired; the banks are going to keep those that are displaced by Erma.

Labor organizations had better begin to prepare now for the fact that the purpose of technology is to eliminate labor. If they want to participate in production as producers, they had better begin to agitate for techniques of finance whereby they can acquire, buy, pay for, and employ capital. The capital instrument is supplanting man in the production of wealth.

I define a capitalist as a man who receives from capital sources at least half the income that he spends on consumption. Now, that is a fair definition. By this definition, one-half of 1 percent of the American population are capitalists.

Mr. Haber: I certainly appreciate the remarks that the panelists have made, and I am quite sympathetic to Mr. Kelso's remarks. I would like to call your attention to the fact that the so-called technological revolution occurred, in fact, prior to the so-called space age.

Mr. Kelso: Mere acceleration.

Mr. Haber: That is right. We were in the age before many of us—in fact, almost all of us—appreciated what had happened. Whether you like it or not, it will not go away. We might shut off one program or another, but it is here; it is feeding on itself. The accumulation of knowledge that has been generated is snowballing—and this, in fact, does present a very real problem.

The problem is further aggravated by the fact—and this fact disturbs me—that there is a tendency to say that if the space programs only went away, this wealth could be employed elsewhere. The problem is far more serious than that. Until there is an educated electorate who can approach the social problems we are faced with on the basis of knowledge and freedom from prejudice, we will not solve this problem. If the modern age has done nothing more for us, it has generated an intense preoccupation with education. This is obviously no solution to the overall problem, but at least it is a very important step. I think that our training programs will help, but they are a drop in the bucket.

H. D. Lowrey: I would hate to think that we would stop the space program right now so that we could do something differently for a group of people who, I believe, are supported best by this particular method. The last thing we can possibly afford is to stop it. It is doing more than any other one thing I can see at this time to produce a new and different technology. In our particular company in the South, we are training a good many people for a brandnew kind of thing in a brandnew area—in a brandnew part of this country that has never experienced anything like this before. It will bring a new concept of living and a new idea for this area of the South.

I think that it can do wonders to increase our overall capability for learning, for doing, and for accomplishing things for the average man—the one that needs the union for his support and wants it.

Mr. Johnson: I agree there is an unemployment problem; unemployment is actually increasing, rather than decreasing. But I do not believe that technology has the responsibility for the increase in unemployment, and this is what seems to be coming out of this discussion. Without these new technologies, without the billion-dollar electronic industry which is one of the things that is supposedly throwing some people out of work, we would really have unemployment. The technologies have helped, rather than hurt.

Mr. Kelso: The last thing I would advocate is a cessation of the space industry, nor do I say it is the responsibility of technology to provide employment. I say just the reverse; its purpose is to eliminate employment. But the conclusion that should be distilled from my remarks is simply this: It is important that we take a look at our political, economic, and legal structure in order that we may simultaneously build the economic power to consume as we build the industrial power to produce. If we do that in the space age, we can afford any other kind of age. This is where we should focus our attention. As I have said, I think the big culprit lies in the world of finance.

Mr. Lacklen: I would like to reiterate that a higher percentage of our work force needs to be more highly trained. Those with the lower levels of skills, unless they can raise their level. are going to be permanently unemployed. Because of the nature of our society, a higher and higher percentage of skilled workers will be required. Our real problem is to train people who are unskilled.

SUMMARY SEMINAR G

What Immediate Progress Can Be Made to Apply New Space and Scientific Technology to Greater Use in Our Urban and Industrial Communities?

Chairman: DR. C. EASTON ROTHWELL,
President, Mills College

INTRODUCTORY REMARKS

DONALD L. PUTT, Lieutenant General, USAF (Retired); Vice President, United Aircraft Corporation; U.S. Delegate to the NATO Advisory Group for Aeronautical Research and Development. Formerly: President, United Technology Corp.; Military Director of the Scientific Advisory Board to the Air Force Chief of Staff; Chairman, Air Force Scientific Advisory Board; other major military assignments; Past President, Institute of Aerospace Sciences. Carnegie Institute of Technology (BS); California Institute of Technology (MS).

PANELISTS

RICHARD E. HORNER, Senior Vice President, Northrop Corporation and General Manager, Northrop Space Laboratories; Chairman, Missiles and Space Council of Aerospace Industries Association. Formerly: Assistant Secretary of the Air Force; Associate Administrator, NASA; Technical Director, Air Force Flight Test Center; Member, Air Force Science Advisory Board. University of Minnesota (BS); Princeton University (MS).

DR. BURNHAM KELLY, Dean, School of Architecture, Cornell University. Formerly: Faculty member, Massachusetts Institute of Technology; Practice of Law; Director, Albert E. Bemis Foundation (housing research); Staff, National Research Council and Office of Scientific Research and Development; Author, *The Prefabrication of Houses* and others. Williams College (AB); Harvard University (LLB); Massachusetts Institute of Technology (MCP).

DR. WILLIAM H. PICKERING, Director, Jet Propulsion Laboratory, California Institute of Technology; Professor of Electrical Engineering, California Institute of Technology. Formerly: Member, USAF Science Advisory Board; Technical Panel Earth Satellite Program. Recipient, Wyld Memorial Award and Space Flight Achievement Award; Fellow, Institute of Radio Engineers; Past President, American Rocket Society; President, American Institute of Aeronautics and Astronautics. California Institute of Technology (BS, MS, PhD).

DR. SAMUEL SILVER, Director, Space Sciences Laboratory, University of California; Professor of Electrical Engineering, University of California, Berkeley. Formerly: Faculty member, University of Oklahoma, Massachusetts Institute of Technology; Physicist, Naval Research Laboratory; Director, Electronics Research Laboratory, University of California. Fellow, Institute of Radio Engineers and American Physical Society. Temple University (AB, MA, LLD); Massachusetts Institute of Technology (PhD).

DR. ROBERT C. WOOD, Professor of Economics and Director of the MIT Field Study Program for Political Education, Massachusetts Institute of Technology. Formerly: Faculty member, Harvard University; Staff, U.S. Bureau of the Budget; Associate Director, Legislative Reference Service, State of Florida; Author, *Suburbia; Its People and Their Politics*, *1400 Governments* and others. Princeton University (AB); Harvard University (MPA, PhD).

DR. LOUIS WINNICK, Program Associate, The Ford Foundation. Formerly: Chief, Planning and Research Department, New York City Housing and Redevelopment Board; Research Director, New York City Planning Commission; Director, New York State Commission on Economic Expansion; Faculty member and researcher, Columbia University, Rutgers University, and Brooklyn College. Brooklyn College (BA); Columbia University (MA, PhD).

WHAT IMMEDIATE PROGRESS CAN BE MADE TO APPLY NEW SPACE AND SCIENTIFIC TECHNOLOGY TO GREATER USE IN OUR URBAN AND INDUSTRIAL COMMUNITIES?

INTRODUCTORY REMARKS

Gen. Donald L. Putt

This panel session has been labeled the summary session, and perhaps in some respects we can call it "the last roundup." I would prefer to call it an interpretive summary because, knowing the panelists, I am sure that they will summarize in the light of their own interpretation of what they have heard and seen at this conference. Much of substance has been said, and many good ideas have been expressed that bear on the objectives of this conference. If all these words are to be translated into action, much continuous effort will be required on the part of many people. A permanent committee has just been established to insure this effort.

I would like to think of this panel as the first step in the distillation process to extract from all that has been said some of the good ideas and to put them in specific form. It is hoped that one or more specific recommendations will be made for action that might be taken in the future through the permanent committee that is being formed.

I would like to refer to the specific question of our panel, "What Immediate Progress Can Be Made To Apply New Space and Scientific Technology to Greater Use in Our Urban and Industrial Communities?" It seems to me that the desired emphasis should be on the word "immediate." This panel will try to identify some of the areas in which immediate progress can be made. Each of these panelists was assigned to cover one of the panel sessions, and each will distill from the proceedings of that panel what he thinks was most important.

PANEL DISCUSSION

Richard E. Horner: My assignment was to monitor and summarize the panel entitled "Developing and Maintaining Open Channels of Communications Between the Laboratory, Industry, and the Community."

Certainly it is a complex question and one that every industrial concern is very much aware of, especially if there exists in the company a central laboratory. Just the process of transferring information within the company from the operating division to the central laboratory and back has always been a major problem.

The keynote speaker of the panel, Dr. George Simpson, suggested that there are three categories of communications channels—communications needs—of significance. One is the daily problem of the laboratory investigator's communication with his line of management, and the reverse. This channel is essential to afford sympathetic understanding by management for the provision of resources, and it is important in the other direction to insure proper usage of the information generated by the investigator.

The second communication need concerns the mass communications problem, the mass of information generated by the tremendous research and development program in this nation and its communication to the large body of interested people. This, of course is the classical education problem.

The third category is the focused communications problem, that is, the application of discrete sums of information to specific problems such as the problems of urban areas.

Dr. Simpson pointed out that there are at least three prerequisites for successful solutions to this third problem of communications. The first is a source of competent knowledge that is immediate and related closely enough to those it supplies to inspire complete confidence. An example is the agricultural experiment station, which usually exists in the local community and where, for example, the housewife can call to find out why her strawberry leaves are turning brown and get an almost immediate answer. Another example is the local university that performs this function in the community, even though not as its primary duty.

The second prerequisite is a structure of action, such as conferences, periodic reports, and publications, which implement the transfer of information.

And the third is the motivation for the transfer of information. This motivation can take several forms, personal or general in nature. Some examples are economic motivation, social-interest motivation, and political interest.

The panelists pointed out that laboratory investigators, particularly, need training in the communication sciences; that all too frequently laboratory investigators really feel their job has been completed when they write a report, which is usually in their own language and frequently not understandable to the recipient. There is little indication that they really want to "sell" their ideas.

Panelists also commented on the problem of discrimination of information. There have been several references in this conference to the tremendous volume of information and the problem that is created; and it seems that possibly almost as severe a problem as transferring the good information is the problem of rejecting the bad, the duplicative information. Somebody has observed that if you stack up all the technical reports and scramble to the top, it might be a more certain way of getting to the moon.

Another comment was to the effect that there are two kinds of information problems. In the first case the problem is recognized and is subject to reduction by a search through all of the information for applications. Then there is the other case, in which the problem is identified only by the availability of the answer. Frequently we have answers to questions that have not been asked.

The observation was made that there are—because of the rules of our society, of our free economy—many mechanisms which exist specifically to inhibit the process of information flow. Into this category, of course, fall such things as patents and copyrights; they exist for the purpose of motivating information flow, but they actually inhibit the breadth of transference.

There are other mechanisms of government, such as security and the source selection process. I think it was Dr. DeFrance who mentioned with some nostalgia that his particular laboratory had progressed into an age where industry members with whom he had formerly cooperated very closely must now be treated at arm's length in the process of putting out large sums of public funds.

In fulfilling my responsibility of distilling one suggestion for immediate operation, I have taken the liberty of making a fairly comprehensive suggestion, which I think might be accused of being really more than one. The suggestion that I think comes through all of the presentations in this area is to establish and encourage *planned* mechanisms for transference of information. This is a responsibility of industry. It is a responsibility of the university. It is a responsibility of the government. The need for doing this was, I thought, very well stated by Dr. Kimball: "If we really expect the benefits of the space program to accrue to our urban society by spillover, it just isn't going to happen." So there is a requirement for these planned mechanisms.

What are some examples of such planned mechanisms? To begin with, more attention needs to be given to understanding each other's problems. There will not be good communications between industry, the university, and government until there is a sympathetic understanding of the other fellow's problem, so that each speaks the other's language with an accent that can be understood.

Specifically, in industry, there is a tremendous opportunity for individual companies to put their existing programs of communications, and especially communications with universities, into order. Every company that I know of has a variety of program elements in company-university relationships. Sometimes they are not recognized as such, but every company has consultants from the academic community. Most companies are engaged in a grants program. They have contract relationships with universities. If you look at these programs carefully, you frequently find they are stepping on each other's toes. They are in conflict. The company occasionally hires the professor that it is trying to support through a contract activity. Just the coordination of these programs would be a very effective effort for the industry to undertake.

In the university element of society, as was mentioned by Dr. Libby, there is a wonderful opportunity to make greater use of extension courses to educate the working element of the adult public. And coupled with this, of course, are other mechanics for integrating new information into the academic program.

On the side of the Government, perhaps the most fruitful thing the Government can do is to continue to expand the mechanics for encouraging industry-university relationships. There is also a possibility that the Government could make a major contribution by considering a revolutionary change in Government-industry contractual relationships. These relationships were generated early in the 1940's in the chaos of World War II and are still largely in effect today; a segment of the American industry is to a large degree subsidized. We are not really gaining all the advantages of the free-enterprise system. It is extremely difficult for an industry that lives by Government-sponsored research and development to go into a commercial or consumer products business without establishing a completely separate corporate entity. There is a reason for this, and the situation can be fairly easily corrected.

Dr. Burnham Kelly: My assignment was the seminar on "What Specific Implications Does Expanding Technology Have Upon the Problems of Metropolitan Areas?" I assure you this was a real pleasure.

Martin Meyerson gave the principal talk. He opened by stressing the inherent complexity of urban problems and the huge capital costs necessary to exploit technological advances, but he soon turned to the business of teasing our imaginations. Paraphrasing Mr. Meyerson's questions: Do we, in developed societies, recognize the extraordinary shift in values that seems to occur with economic maturity? Have we fully observed the hedonistic, play-oriented public that serves as the base for our economy of frivolous consumption, while the norms of work and study represented by men such as those at this conference retreat to a new kind of monastic order, complete with long hours and vows—or at least protestations of poverty and of obedience to truth? What about the implications of some of the biological research, that man may approximate immorality, perhaps suspended in frozen storage until manmade viscera can be substituted for the aging ones supplied by nature? Not the technological implications interest Mr. Meyerson, but those of allocation. Who is to be saved, the living or the unborn? The privileged or the underdeveloped? And what is going to happen to our ethical principles when we have immortality, or a reasonable approximation of it, to cope with?

On the other hand, at the other extreme, what is going to be the impact of the esthetics of design, as the sense or motion that has always stirred the imagination of designers leaves our familiar atmosphere and concerns itself with outer space? Obviously, streamlining and simplicity will be replaced. But what with? With emphasis on the improvised and the disposable, or a return to the reassurance of elaborate detail?

Stressing the importance of stretching our knowledge of urban affairs, Meyerson finds that at one and the same time we *know* more than we *do*, checked as we are by problems of capital, manpower, and the political advantages of the status quo, and we *do* more than we *know*, drawing our very best students into the most specialized refinements, while the Russians and the Japanese train theirs to cope with more mundane but probably more crucial problems of modern urban living.

The first commentator was Werner Hirsch who, accepting individualism and the love affair with the automobile as hallmarks of the American style and factors in our tendency to move along and throw away waste rather than settle down and cope with repairs, painted a picture of private underground transportation based on new tunneling potentials and on battery-electric automobiles, with resulting improvements on the surface, both in the general environment and in the efficiency of land allocation. He also noted a blossoming interest in culture among the public, and commented on the chance that science-stimulated consumer demand may make it actually harder in the future for governments to bleed off enough money to cope effectively with such problems as education, crime, and juvenile delinquency.

Carl Stover then pointed out that technology must relate to all of life. Therefore, our concern must be not with what can be done but with what is worth doing. If, as seems clear, technology has given us our cities, it has also obviously given us their problems. To do better we must have a reasoned analysis of what cities ought to be. Otherwise technology becomes, in his words, "abnormative." The main lesson of the space effort, Stover says, is how to go about a complex research job like ours. Some fallout of applications should take place, but we will make progress on the urban front when we start with the problems that need solving and not with the findings that need application. No one would expect to reach the moon on the spin-off from an urban research effort. Required is a greater willingness to guide technology than has thus far been shown.

General Draper and John Gunther then suggested that, bad as cities may seem, people seem to like them, and the failure to solve their problems cannot be attributed to their current governmental structure.

On these points most of the discussion of the audience turned into a conflict of differing opinions.

For me the conference has been most rewarding. An understandable concern has been expressed to find applications for research findings in the routines of urban living and municipal housekeeping. But a number of the speakers have tackled the more comprehensive problems head on. If, as Robert Solo suggested, the city is not an effective organization for applying the findings of science, I would agree with Louis Fong that some new organizational approach must be developed to help it become one. The important contribution to come from NASA research is not the fallout from special studies, but the possibility of applying to modern, metropolitan complexity a new and comprehensive research method. I agree with Karl Wolf that the more powerful the organization and the wider its scope, the greater the chances of success. In the end, I believe the concern will stretch so far beyond municipal limits that the effective organization for such research may well be the State, making use of a regional framework that is at best only suggested in our States at the present time.

If I may make one recommendation to the permanent committee, it is that the initial stages of so comprehensive a research effort take full advantage of any special situation in which many of the political, social, and economic variables can be reduced or even eliminated and the operation thus made manageable. Rather than start with a real pilot city, for example, I would work first with the special communities to be built overseas by the armed services or other Government agencies, in which objectives would be much the same but implementation problems somewhat simplified. Indeed, I would take advantage of any such situation to explore systematically, for almost the first time, the benefits that might result if one objective were to see how much could be obtained under a charge to minimize—or even to reduce—the level of technological complexity instead of ever-increasing it.

Another area for first study, and one richly deserving attention, is the outer fringe of the major metropolitan areas, areas now rural or open but statistically certain to be ground up as the wave of urbanism reaches them in the next decade or so. We at Cornell are deeply concerned with these areas because, although they clearly will undergo the greatest change in land use, in valuation, in social organization, and in political structure, and although cumulatively they represent by far the largest area of urban problem or opportunity, they are now the least studied and have the least organization or resources for study. In addition—and this is by no means unimportant to a research man—by virtue of the fact they do lie open at present and that the threatened change has not yet occurred, these areas are much more interesting to university scholars. They offer the chance of seeking useful insights without the complications and frustrations of dealing with an actually existing urban body politic.

Finally, I am glad to note that one speaker, Karl Wolf, dared to include the artist on his team, for we tend to forget the towering importance of the abstract motivating forces of art. Because they are intangible and hard to evaluate, they tend to be omitted from our careful calculations; but they are high motivations of the urban citizen whom we hope to serve—higher by far than even he usually recognizes consciously. To illustrate: There is a city in the United States that violates most of the first principles of sound urban planning. Its land use is chaotic; its streets come in patches of gridiron fitted neither to themselves nor to their topography; its "in-town" houses are usually made of wood frame and are three- or four-story walkups. Yet it is considered here and abroad one of the most attractive cities in the world. It is, of course, San Francisco.

Let me close by pointing out that conferences, if they expect to aim high, are held in places like Dunsmuir House.

Dr. William Pickering: I was concerned primarily with the session entitled "What Scientific Developments Will Affect the Transportation, Communication, Power Resources, and Construction Industries in the Years Immediately Ahead?" It seemed to me that session was indeed attempting to get to the heart of the problem, because surely most of the problems which we have been concerned with in this conference deal with the evolution of technology in the immediate past and the prospects in the immediate future. Dr. Baker set the tone with his discussion of the broad spectrum of technological development which we can expect, and this will have effect on all forms of city life.

It is clear that science and technology will continue to develop exponentially. This has been the trend for the past hundred years or so. There is absolutely no reason to believe the trend will change. When we see the amounts of money that are being put into research funds these days, we can certainly be assured that science and technology are indeed going to continue to develop very rapidly. Therefore, civilization as a whole is in a very dynamic phase. The effects of science and technology are reaching into all parts of life, and we can expect, then, changes which will follow with the developments in science.

The elements of society and government which can recognize and adapt themselves to this dynamism will therefore be the ones best fitted to survive in the future. Clearly, with the rapidly changing world, we must recognize that the status quo will change and we must be prepared to accept this change. I think, as a matter of fact, one of the interesting points that was brought out by Dr. Hollomon is pertinent here, namely that the growth of science and technology has brought about a shift in the value of our natural resources. From the older concepts of land or mineral wealth as being our prime natural resource, our most important raw material is now becoming technical skills. Fortunately, this is a raw material which can be developed, and therefore the nation or the region which develops these skilled personnel will have the first requirement for success in the future. Of course, the way in which the nation or region uses these skills will determine its success. It is not enough just to have the technical skills; they must be properly used.

If we look at the problem from the urban point of view, scientific developments have resulted in new types of industry and corresponding changes in the requirements for and the opportunities available to the work force. It is quite clear that, particularly in some of the more advanced technical industries, the nature of the work force is completely different from what it was a few years ago. Also, the changing patterns of physical development which

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have resulted from the developments in transportation and communications are obviously likewise affecting the urban situation.

It seems to me that existing urban centers have largely evolved as a consequence of the scientific and technological developments of the 19th century. The science and technology of the twentieth century are rapidly making many features of these urban centers not only obsolete but unnecessary. When I think about the space program and its effect in these areas, it seems to me that one of the most important contributions of space—and this has been commented on by some of the other speakers and panelists—is that it requires the engineering of very large, complex systems. These large engineering systems are developing new techniques in mathematics and in engineering in order to understand and to be able to control the systems themselves. When we look at the problems of urban life, we note that we are dealing with very large, complex systems with numerous feedback loops. And, as any engineer knows, the large system with many feedback loops is a very complex system to understand. It seems to me that many of the tools which are being developed for the space program will indeed have applications in these areas.

In the light of this picture of technological dynamics, I ask myself: What immediate program does this suggest? I think the most important one is to get real agreement on goals. If a group of people—whether it is an urban group, an industrial group, or any other—can really understand what it is trying to do, then the programs usually follow rather logically.

Dr. Samuel Silver: I would like to make some observations in general with respect to the things that have struck me during the conference.

One of the points that I felt needed more clarification is that we have to have more of an analysis of the needs. What are these urban problems to which we wish to direct ourselves, and where do we wish to go and why? The question arises: Why the city? The discussions seem to have taken the city as something that was a fact and would therefore remain forever. This is a rather natural human instinct. But the question is: Will science and technology and the other forces that we generate as we go along really maintain the city as an institution in the future? Is the city going to be the thing that we have seen in the past 20 years or is the city to be something entirely different? In fact, what is it that makes a city, rather than a large collection of villages, and what are the problems that will be generated by the combination of developing forces?

In our cities there are many buildings that contain nothing more than offices. They certainly have a function; they certainly do a great deal of work. In those offices sit an enormous number of secretaries. Now, I have not really been able to understand why all these people have to be collected in one place at any one time, and why the method of operation has to proceed on this corporate basis—I mean "corporate" in the sense of bodies involved, rather than in a financial or institutional sense. Perhaps we could go back to the medieval situation and have these various people do their rather routine occupations in their own houses. The boss could simply dictate letters and send them over the teletype. I think we have to apply to the question of the "city" some new thoughts, or at least ask some questions about why it should go on in the way it has gone on in the past.

A great deal has been said during the conference about research, about science and technology, and these terms are always used in a sort of embodied sense, as though science is an organized thing that is doing something to something else which is organized. We should begin to give some thought to the difference between what I would call the substantive content of science—the results of research—and the methodology of research. One thing that a scientist—and I am talking now about a scientist in the pure sense—does not do is use a scientific method in carrying out his own individual research. It should not, therefore, be assumed that the scientist has some power that will enable him to approach an urban problem in any better fashion than any other irrational individual.

On the other hand universities *can* be awakened to a sense of responsibility. All you have to do is take the trouble to tell them what the problem really is, rather than demand that they do something and accuse them of introversion and introspection.

I would like to take my usual slap at the computer and so-called systems theory. Not that I deny the existence of computers; I wish I could! And neither do I deny the importance of systems theory. But one must remember that these things are still devices, and that they are subject to the human machinations which lie behind them and are subject also to the intents to which they are to be put. As far as system analysis of society is concerned, it is a fine thing if we do not go to the extreme—as is done in some of the books and curricula on system theory—of reducing society to a black box. It is black enough as it is, and we should have a more human approach to the situation.

Another point current in the discussions was that of education. This is a rather favorite word with everybody. We feel that we are going to solve juvenile delinquency by education; we are going to solve traffic problems by education; and so on. And yet no one has really asked what we are talking about. What is the basis for this education which is going to solve juvenile delinquency? I want to point out that we can give an excellent course on safe cracking and on embezzlement. What we really must reestablish is a base of values for our society; this is an extremely important problem for the university, for the city, and for a conference of this sort and its followup phases.

Dr. Robert Wood: I share with my colleagues a sense of dismay in trying to distill into a simple summary the complex bill of fare that has been presented here. An additional inhibition is the fact that though I am listed as an "economist," because M.I.T. still keeps social sciences in the same department, I am really a political scientist. I spend most of my working time studying and trying to understand the behavior of urban politicians, and more recently, of scientists and engineers engaged in the space enterprise. I work only in the basic—not the applied—field, so that I am underfinanced and my work is innocent, which gives me a particular kind of backdrop and compulsion to my assignment. My special charge here is to judge this conference's contribution to our understanding of the impact of space R&D on regional economic development.

I think, on the one hand, conferences can come out where they began, with the same set of self-fulfilling prophecies. When conferences do that, they are unnecessary. They can, on the other hand, expose—and sometimes brutally—the fallaciousness of the proposition that generated the convocation. If they do that, it seems to me we have to admit that they are failures. And finally, they can reformulate the first propositions by the impact of a set of countervailing hypotheses and propositions and turn them into issues which are subject to future work, to action programs, and to future empirical testing. In that case, in my judgment, a conference becomes a success. I place this conference in that category, for what I think we have witnessed is something like the following.

The original set of four propositions, stated briefly and crudely, were as follows: First, that the space age really means the golden promise of a new technology which will revitalize our urban communities and our industrial complex; second, that at the heart of the space age is the present program, that it is far more than a man-on-the-moon task and that, indeed, it is a major underpinning of a now sluggish economy and a major stimulus for the reshaping of urban communities; third, that, given obvious and commonsense dissemination of information to industry and to the urban community, private industry can tap the promise of the new technology, will generate a new mix of products, and will find a new array of goods eagerly awaited by consumers; and fourth, that, given the necessary investment of new facilities by NASA and other sources, alert and imaginative civic and political leaders in progressive communities will utilize both the new investment and the new knowledge to revitalize their economic, social, and political systems.

The counterpropositions throughout the sessions came fast and hard. Congressman Miller raised the issue of whether space-oriented R&D met the most urgent needs that technology can be expected to fulfill and raised those specters of problems, mostly overseas; and he wondered about the coupling. Dr. Gordon questioned whether R&D itself could be looked upon as providing the quantum jump for revitalizing and changing our economy. Dr. Wiesner inquired as to the sophistication with which we now manage the R&D enterprise at the public level. Dr. Kimball continued Dr. Wiesner's excursion by asking, similarly, whether private industry and university management were up to the new task we provided for them. And, finally, Dr. Hollomon spoke on the far more fundamental revisions in economic character as the kinds of real needs to be explored.

Against these countercharges and counterpropositions, the panelists found themselves singularly hard put for immediate details and immediate answers. They found that the basis of oral discussion and the dialectic did not provide us, at the close of this conference, with simple answers. But, as searching as these counterpropositions and these inquiries were, I do not think they were destructive to the propositions with which we began. They made it clear, I think, that these propositions are not self-evident truths, but they did nothing fundamentally to change the plausibility and the defensibility of the conference.

The original four propositions can now be reexamined. In place of the notion of a golden age of space we have, as Dr. Pickering has noted, a radical discontinuity in our society, a set of changes that have come so fast and so quickly that although they present opportunities, they also present problems. In place of a notion that the space effort, per se, can be at the heart of our endeavor, it is far more plausible to consider the generality of a man-to-the-moon mission; what the space scientists are concerned with is putting human beings in a new environment. Then, surely, they must have to learn more about the old environment and the behavior of the human being in it.

In place of industry simply and automatically tapping the results of new resources, we have the propositions Mr. Horner has expounded—the problems of a subsidized industry finding diversification in the changeover from public mission into private consumer missions, and a set of problems that bring a set of radical readjustments within industry and in its communication with itself.

And, finally, we replace the notion that growth can come through space R&D to any economic mix of any major metropolitan region, simply through the booster complex of the chamber of commerce. A whole new set of other forces are in being for those who would engineer an urban turnabout for any community. The humanities of public life, the living conditions of scientists and engineers, the educational enterprise and capital of the community, and the energy and alertness of its bureaucracy become far more important factors than the old formula of economic location that recognized only markets, labor, and transportation as the focal points of the city. Cities today are made and shaped not by the market place, not by the impersonal interactions of gross physical and economic forces, but by public policy. In short, what I think we have discovered in our exploration of all four of our propositions is that science and technology have done to the city what they have done to any part of human endeavor they have touched. They have freed us more and more from our environment; they have given us more opportunity to manipulate it.

What immediate applications and what immediate implications are offered by these reformulations of the propositions? First, however we seek to make the coupling between science R&D and the urban community and industry, it will not happen naturally. Good will and good intentions are not enough. Second, the mechanisms of the coupling are critical to the transfer. The systematic analysis and systems analysis with all of its problems, involving particularly work in the life sciences and the management of free enterprises, are primarily the areas in which we have to work today. As we find out more about political and social systems, we may not find them as tractable or as easily manipulated and changed as they might appear to be on first inspection.

Third, I think the major implication of this conference has been that the public sector of our local economies will expand as a force in our life. I share with Dr. Silver a sense of uncomfortableness about how the university may be changed and the radical readjustments required. But anyone in the academic community who expects to retain a version of the old university is not dealing with today's reality; he is having a love affair with an academic ghost.

And, finally, I think that the implications of this conference present two special obligations on the part of the participants. First, this conference should accelerate NASA's search for new ways to answer *what* industry and *what* community should profit by their activities and by their missions, and a search and a continuation on their part for finding criteria that take them far beyond the old days and old patterns of government pork-barrel allocation for regional locations. The second major implication of this conference concerns the city of Oakland. Whatever its citizens undertake in their continuing organization, whatever activities they engage in to change the shape and form of Oakland, should not be done parochially or in the spirit of a search for self-identity. It has to be done within the entire metropolitan area of which they are a part. Oakland may well be the beginning of a pilot study for a coupling of science and R&D into the urban community, but it would be a shame if Oakland were the only community within this area to profit.

And so, the conference to me has said that work remains to be done, that reflection and thinking are in order for those with a continuing responsibility. Because work remains to be done and reflection and thinking are in order, I think the conference must be judged a success.

Dr. Louis Winnick: The sum of what everybody has been thinking and saying seems to me to be this: the problem of our times is one of imbalance and opportunity.

We have heard a great deal about the imbalance. We heard about a serious and critical imbalance in supply and demand of labor, with a shortage of many types of skills—not only those of the space age but also such mundane things as stenographers—and a growing surplus of nonskilled persons in this country. There is an imbalance between the supply and demand of technology. Dr. Kimball effectively brought out the fact that technology has been growing faster than our ability to make use of it. We are not making sufficient demands on our technological resources, partly because we do not know they are there, which is an imperfection in the market.

The third imbalance, which Congressman Miller, Dr. Silver, and Dr. Wood all have alluded to, is an imbalance between our knowledge and our wisdom. We do not know what to do with our knowledge. We do not know how to apply it to better our society. I am in full accord with what Dr. Silver said in another context; there is not an organism called science which operates on another organism called humanity in the urban areas. Instead, there is a diffuse collection of groups of people and subgroups of people. There are no rationales to apply to the urban area.

Economists and political scientists can lay down a physical program for metropolitan areas that is infinitely more rational than any which exists. We do not know how to apply this rationality. I do not think I fully share Dr. Wood's view—and this is an ancient argument—that public policy will shape the metropolitan area. This again implies an entity that acts on people. I think the process is quite the other way around, and I think the public policy and our political system are shaped by a larger collection of blocs of people.

I am still an old-fashioned believer in Newtonian mechanics with its axiom that where you have imbalance you also have a potential for change or movement, and these imbalances are setting up movements. The imbalances of the metropolitan areas are setting up new forces which will operate in the future. One can only say there is probably a law of the universe that all new change brings with it a new set of imbalances. This law of the universe, if it is such, will probably be a continuing one.

GENERAL DISCUSSION

Congressman Jeffery Cohelan: I wonder if Mr. Horner would elaborate on this business about government contracts and how we can change these contract relationships?

Mr. Horner: I stated that our industry-government relationships still are too close to being identical with those that were generated during World War II. What we know today as the aerospace-electronics industry, which is primarily involved in Government business and largely involved in Government R&D business, was then almost nonexistent. In order to create this industry for the needs of World War II, it was necessary to go a long way toward providing facilities, providing risk capital, and eliminating the risk from many of the management decisions. The way most of the risk was eliminated from management decision was by creating a contracting structure which permitted in overhead, or charged to the burden rate, substantially all of the company-sponsored research and development program and the bidding or proposal expenses.

In the past 20 years, there has been an evolution. Because of the difficulty of red tape and the difficulty of acquiring government facilities, most of the industry has gone largely to company facilities. They have found this is the best way to spend what resources they could generate themselves in order to retain or optimize their competitive position. But the industry still operates almost entirely on indirectly acquired Government funds in its own company-sponsored research and development and its own bidding expenses.

This has a major influence on the industry decision-making process, because the management, whether consciously or not, makes its decisions as though it were spending somebody else's money when it decides what programs it is going to bid on and in what programs it is going to invest its R&D resources.

This kind of arrangement is no longer necessary. The industry is mature now. There is no lack of capital. I believe a banker on one of the panels mentioned that the financial world stands ready to double its investment in the industry if that is necessary, and certainly that kind of investment is not at all necessary. The industry averages—and I emphasize that this is the industry that is doing business on a sort of 90- to 100-percent basis with the Government—the industry averages 4 percent of its sales in its company-sponsored research and development program and its company-sponsored bidding expense or sales program. This has created a situation that makes virtually impossible the use of an organization in commercial and industrial products or consumer products if it has the Government as its customer. The two decision-making processes are entirely different.

The system exists largely through inertia. The industry would find it very difficult to take the initiative in turning down the opportunity of this kind of Government subsidy. As a matter of fact, individual companies could not possibly do it, and it would be very difficult for the industry to raise enough confidence in Government processes so that it could even suggest this, because obviously there is accommodation in Government-management procedures here. Whenever the matter is discussed, there is always a question on industry's side as to whether the Government management procedures would be really changed to accommodate this new method of doing business.

There is certainly adequate room in the statutory limitations on fees to compensate for such a change in management structure. A complete accommodation is not necessary, because the individual companies would run much more efficiently and make sounder management decisions if they in truth were managing their own business with their own money.

There are many, many other facets to this operation, and it is a fairly complex subject.

Stanley E. McCaffrey: The panel on which I served as presiding officer developed information and made seven points which in a way synthesize the purpose of the conference.

The theme of the panel was: "Can New Space and Scientific Technology Be Applied to Basic Community Problems of Water Supply, Air Pollution, Public Health and Safety, and Sanitation?" The answer was "Yes," and examples were given of scientific developments that pertained to these problems. However, these are not necessarily developments from NASA, but from other scientific sources as well. Related to that there was an admonition that we not expect too much, that we not oversell, which seemed to be an important point as well.

Second, Louis Fong made the very important point that there has to be a process of translation from these scientific developments to application, which I think we have learned throughout this conference.

The third point was that there needs to be a better compilation of the knowledge that is already available, much of which has been developed through the long years. This available knowledge could be a rich source of information.

The fourth point was a suggestion that there is a need for a center for research to compile knowledge and develop new knowledge on urban problems.

Fifth, it was suggested that the problem could be more a matter of political organization than of application of these matters to urban affairs.

Sixth, the question was asked: Can modern computer technology be utilized in urban problems? The answer to that was: Yes, it can be, and on many specific matters, such as transportation planning, it is being used. But—and this was the final and seventh point made in the panel—when all is said and done, the computer is only as good as the program which is fed into it. This requires human judgment. Indeed, in this whole question of the application of technology to urban problems, human judgment perhaps is the most important factor of all.

Question: Why shouldn't this area develop and establish a true technical information center, which incorporates the things we already have in ASTIA and materials that are in the university libraries, but which is fully organized and equipped with modern indexing for rapid search and retrieval?

Dr. Pickering: Information retrieval is a key problem in a great many areas of technology at the present time. Nobody has a good solution, really, to the problem of information retrieval in a limited way—much less in the sense of providing information for the problems of a whole area.

However, this is a field which is developing very rapidly. Perhaps within a few years it would make sense to talk about a centralized information retrieval center for an area. But until this has been solved in a much more limited sense, I do not think you would gain a great deal by trying to put in such a center at this time.

The key to information storage and retrieval is abstracting and indexing. Out of the great mass of printed material which exists today, how do you set up a sensible indexing and abstracting service? In limited areas this is being developed. By "limited areas" I mean limited segments of the technology. A great many experiments are being conducted with computer programing and the like, and I believe that within a short time, the state of our knowledge in this will be much better than it is today. In order for it to be effective, these computer inputs must be associated with published material, so that the computer can have material to work with. This is a process which will take place, but I do not think we are ready for it yet.

Dr. Karl Wolf: The subject of "imbalance" was raised by Dr. Winnick. Historically, there has always been imbalance between knowledge and available technology and its market. The personal papers of some of the inventors reveal that they frequently had specific commercial applications in mind, but they were always ahead of their time. Until about 1950 or 1955, we were not so spoiled. We were saying: "Well, it takes care of itself. The knowledge is there—and the individual effort. If we leave it, it will find some way into the economy by itself." The truly revolutionary approach that we are trying to take here is an ambitious one, to look systematically at the knowledge and technology that is created and try to feed it back into the economy.

I do not think we have the choice, so frequently stated, between pursuing the NASA program and combating juvenile delinquency. The NASA program is, like defense, forced upon us by foreign policy decisions. Looking at it in this way, I think it is a great blessing in disguise. It accumulates knowledge that we are trying to put back systematically. From the NASA world and from the defense world, which deal in physical hardware and physical science, we are trying to make the link and put another dimension on it. This dimension is a socioeconomic one. This is where the opportunity that Dr. Winnick referred to lies.

Louis Kelso: Technology has for perhaps 300 years been the most disturbing force in civilization. Man has never understood it. Man has never been able, really, to cope with it. It disturbs his perhaps half-million-year-old ethical relationship with his environment. It changes the nature of his relationship to that environment. He is still reeling, as it were, from the impact of it.

I believe the wonderful thing about the space effort is that, with its acceleration and its conspicuousness, it is forcing man to consider the significance of technology to his life and to his goals. In terms of economics—and I know economics traditionally has a rather low position in the minds of most men—I consider it one of the most important things in life, not because it relates to the mind or spirit of man, but because man is first an animal and secondly a mind and spirit. It is only as he solves his economic problems that he can begin to live a civilized life and really function as a mind and a spirit.

To tie the problem down very closely, I believe that technology is a process by which man harnesses nature in the economic order to make it work for him, and he has gone a very long way. I am sure he will go a great deal further in the next few decades. No longer can we cling to the ancient myth, which had a great ethical significance, that man is the only producer of wealth. The nonhuman slaves brought forth by technology are today our chief producers of wealth. Just as in our early struggles with the idea of political democracy and individual freedom we sought to protect the property—if you will—of man in his labor power, technology now forces us to consider the concept of property in the nonhuman factor of production.

I believe that it is in this property relationship that social policy can be effective; that diffusion of power—that is, economic power diffused throughout the citizenry—can be counterbalanced by centralized political power. Thus, in the end, this argument points to the deficiency of our techniques of finance, techniques which do not deliberately and systematically create a growing private ownership of the external means of production. In our failure to do this, we are creating an economy the product of which must be redistributed by government. In the course of that redistribution, we are destroying our morality, our initiative, our sense of order and rationality about the life around us. I believe that nothing more useful could come out of this accelerated technology than to force the scientist and the executive to step in and find out what the system is in the economic order. It has been talked about for centuries, but in fact it is not a system as presently understood; it is simply a patchwork of makeshift expedients. This, to me, would begin to pave the way for the tremendous space effort and other things that may be comparable in the decades to come. We could carry the benefits of technology to the 77 million people of the United States who live in privation or poverty, and to the 80 or 85 percent of the world's population who live in preindustrial poverty. Since we can do it, I think we must do it.

Dr. Pickering: I would like to comment, particularly on Dr. Wolf's comments. I think Dr. Winnick's "imbalance" was primarily between knowledge and wisdom. We are arriving at the stage where technologically we can do some rather fantastic things to our environment, whether this is setting off an atomic bomb, controlling the weather, or spreading DDT over a large area. There are many things we can do to our environment which are irreversible, and I think that as time goes on, we are going to find increasing cases where it is essential that the application of technology be done with wisdom. I would like to emphasize the necessity for wisdom in considering the application of knowledge.

Dr. Edward T. Grether: An interesting experiment is just beginning among certain American corporations in reaction to the same problems we have here—that is, the rapid increases in technological change, precision of analysis, and so on, that have created problems for many firms in private sectors.

Twenty-nine of these firms were pulled together by Tom McCabe, the chairman of the board of Scott Paper. Each firm put up, I think, $20,000 a year for 5 years. They want to start first at the grass roots in a most academic way and consider conceptualization, theory, ideas of a very basic sort, with the hope that they can find ways of channeling some of the developments in science and engineering into the operation of these enterprises.

This group might have some significance as a pilot model. They will have a small research staff as a center. From that small research staff, they will reach into the research staffs of the corporations to get their cooperation. The central research staff becomes a kind of coordinating group, but they will be doing the primary and basic work. Also, they expect to reach into the universities. They are going to have some funds to make some grants.

The point is that this is a planned organization to meet a problem, and it is the same problem, I think, that cities have. These business firms are finding themselves lagging in applications of technology, and also they have problems created by the rapid development of science and technology. This is a very new experimental way of trying to cope with this problem.

Dr. Eugene Lee: Dean Kelly has said that we need to concern ourselves with adapting governmental and political institutions to take advantage of scientific technology. I wonder if he would expand on that a bit and if Dr. Wood would then comment.

Dr. Kelly: We are talking constantly about applying science and technology to a series of problems which are not only different in scale, but probably different in kind from the ones we usually cope with. It is not normal, even in the NASA program, to have as an objective the objective of not having an objective. In many aspects of society an important principle is that of leaving open ended many of the issues we face—to allow freedom for later changes in decisions. This is true not only in education, where it is obvious—I would take it any one of us dealing with education would assume that the young men we teach are going to throw out the system we have set up to teach them—but it is also true in our society generally. We need to set up mechanisms, not only physically, but socially and politically as well, which permit people to differ with us, to differ among themselves, to decide to do things in completely different ways from the ways we would do them.

This is not an easy task for science and technology—even science and technology based as broadly as in NASA programs. Perhaps if we recognized the fact that we are making decisions in this area and that there is something to be learned about the decision process and systems analysis approaches, we might be able to work into political organizations a mechanism that would at least comment on and advise on the way the present system copes with these problems, and might from time to time work in some rational improvements.

Dr. Wood: I remember a speech given in another context by James Webb at the American Political Science Association in St. Louis a couple of years ago. Mr. Webb had just assumed the headship of NASA at that time. In describing the program, he questioned whether it was useful either in theory or practice to talk in entity terms of the American corporation or of the government agency as great organizing institutions that function in our American society. He discussed the kinds of close relationships between private and public sectors that now exist in space and defense business, and the difficulty of pinpointing decision-making there.

I think we are in about the same situation with metropolitan areas now. That generation of political scientists of which I was a part in the 1950's moved restlessly to the fore and said "Metropolitan government or bust!"—we busted! I think the notion of formal institutional reform was a case of trying to design facilities before we had basic knowledge of the behavior patterns of the people we dealt with.

I am impressed by how far you can get in the metropolitan area, once you have followed Mr. Webb's space and defense analogy. If you ask yourself why a missile does or does not go up at Canaveral, and you try to pinpoint responsibility among the many industrial concerns and laboratories, you find it an enormously difficult system to analyze or to describe. The same kind of thing, I think, is happening in the metropolitan areas. What is beginning to develop now by couplings and by linkings is a series of halfway houses. There is developing an embryonic political system, one that has to develop before the structures and the institutions appear. I am impressed by the way this system in many metropolitan areas has developed in the last 10 years—councils of the local officials, the establishment of centers of research, and the extension of the 701 program. It is this kind of embryonic, evolutionary pattern that is the most logical. Such a system fits well with what we understand about systems analysis and research.

I am not sure we will ever be able to recognize it formally. I am not sure it will look neat and tidy to an organization and management examiner. I am not sure it will come fast enough to be able to absorb the technology we have to deal with, but I am not a pessimist about the way metropolitan areas are now beginning to move.

Dr. Richard H. Brenneman: I believe we have a resource at this session we have not heard from, and that is the industrialist. We talk about and hear about this "imbalance" and about the fact that we have more technology than we are using. Meanwhile, we have technological unemployment and the need for economic stimulation. We learn, too, about how well agriculture has done with its extension of technology. Are the industrialists persuaded that there is a greater need for the application of technology than we find extant? How is industry trying to achieve this application to the urban situation? If they are persuaded about this particular problem, what methods do the industrialists propose to accomplish this transfer?

Mr. Horner: It seems to me that we have an interdisciplinary group at this conference for a reason. Dean Kelly has suggested that, if we are going to apply this technology to a sample or laboratory urban situation, perhaps we should try to do it in a controlled environment, such as in a foreign theater. I certainly recognize his motivation, but I question whether that really meets the problem.

Reduced to an analogy which I can understand, it is somewhat like an airplane design problem in which only aerodynamics is considered and no attention is paid to propulsion, structure, or function; and although it is a very interesting "sophomore design problem," when you get all through it is not very useful.

We have to face up to these social engineering problems. We have to develop confidence in the understanding of the disciplines in which we are not expert and recognize the interweaving of these disciplinary problems, if we are going to be successful in applying the technology.

There are many, many opportunities for application of technology with which we are all familiar, but which we continuously back away from because of building codes, because of government regulation, because of imagined or real nonacceptance by sectors in our society. We really can solve this problem only by the interdisciplinary approach.

Dr. Kelly: I could not agree more. I did not mean to imply that a limited example would be sufficient, but to suggest that we start in this way. It is extremely difficult to start at the full scale with all the problems involved, and certainly it is going to be hard enough to start even in a limited way.

We have found every time we have studied cities, or even narrow areas such as the housing industry, that while it is very easy to say we could make rapid progress if external restrictions could be eliminated, it is difficult to convince people that this is true. One reason for setting up a study is not so much to prove the facts which you suspected, but rather to make a real demonstration that must be clear to the public at large, to the legislators involved, and so on.

Continuing my illustration of an overseas development, here is the opportunity for an industrial complex to put together not only the structure of the shell, but also the supply and design of the utilities—the location, supply, and creation of the facilities in general—and to do this in such a way as to demonstrate whether there is or is not any truth in the proposition that a comprehensive, intelligent, industrial approach to this problem can really make substantial savings over what we now regard as a relatively inhibited and antiquated system of production. I think most of us will agree with the conclusion that it has not been demonstrated. It has to be demonstrated in some way in order to generate the kind of public support and understanding that will make it possible for us to deal with the external restrictions.

Gen. Putt: I don't think there is any question that industry would rise to the occasion and that it has almost unlimited capacity to apply technology to many things. I think the problem is one of creation of the demand, of education of the consumer, so that when industry produces and markets whatever items it has, the venture will be profitable. Profitability is a really important factor, and I do not believe there is any limitation on what industry can do.

True, some of our productive means are antiquated, and science and technology could tell us a lot about better ways of producing things; but I think the really important thing here is the creation of the demand.

Dr. John J. Grebe: The great contribution that the whole space program may make—and it will be fallout, not planned, not directed, not guided—is the philosophy of the freedom to fail, to make certain experiments that are not going to succeed. We have become so conservative that we have depended on other nations, generally the Europeans, to put across our new inventions before we will accept them. One example is the hover craft that was developed in this country. It was pushed and driven into people's consciousness by various techniques, but nobody paid any attention. The British have built one and have been running it across the English Channel now for more than a year on a schedule of four trips a day, and it has never been late by more than 5 minutes. Think of what this would mean in the San Francisco Bay area—a hover craft going faster than a helicopter, coming from one big parking area, over land, over streets if necessary, to another big parking area or anywhere else.

APPENDIXES

APPENDIX A

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APPENDIX B

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APPENDIX C

ANALYTICAL SUMMARY OF THE CONFERENCE

This Analytical Summary of the Conference was prepared by Stanford Research Institute, Menlo Park, California, at the request of NASA. The objectives were to distill the conference proceedings and to suggest possible action programs for consideration by the Continuing Committee.

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A. INTRODUCTION

The Dunsmuir House Conference on Space, Science, and Urban Life focused on the problems of applying the results of space science and technology in efforts to resolve problems of urban communities. Its objective was to stimulate thought and action with respect to such questions as these:

Can the gains in knowledge and techniques associated with the space program be utilized productively to improve the quality of urban life?

What specific opportunities exist for applying the results of space research and development in urban affairs?

What obstacles impede the use of new technical capabilities in meeting the needs of urban populations?

What technical, political, economic, and social conditions are most conducive to the transfer of scientific and technical developments?

The Conference brought together a distinguished national group of scientists, engineers, authorities on urban affairs, business leaders, and public officials. The record of their deliberations suggests opportunities for using advanced technologies related to the space program in the analysis and resolution of urban problems.

The principal contribution of the Conference was, however, the identification of a number of difficult basic issues that must be dealt with in any effort to take advantage of opportunities of this kind. Clearly, the Conference provided a worthwhile beginning in the consideration of a matter of great complexity; but a long analytical process and difficult decisions lie ahead.

At the conclusion of the Conference, a local Continuing Committee on Space, Science, and Urban Life was formed by leaders in the Bay Area and the Conference sponsors—the National Aeronautics and Space Administration, the Ford Foundation, the University of California, and the City of Oakland. Its purpose is to carry forward the work begun at the Conference, looking toward the development of programs that will achieve concrete results. To assist this Committee, Stanford Research Institute has been asked to analyze the Conference record and to prepare the following agenda of action items for the Continuing Committee.

B. AGENDA FOR THE CONTINUING COMMITTEE

The Institute recommends that the Continuing Committee's agenda be:

1. Initial Policy Decisions:

a. Identification and critical examination of the basic assumptions and problems underlying the attempt to transfer advanced technologies from the space program and related activities to the resolution of urban problems, both generally and in the Bay Area;

b. Determination of the implications of these assumptions and problems for the program of the Continuing Committee;

c. Setting of objectives for the Committee's work;

d. Organization and financing.

2. Program Opportunities:

a. Sponsorship of systematic investigations of problems having strategic importance in the effort to use advanced technologies in meeting urban needs;

b. Implementation of experimental and demonstration programs involving the application of the results of research and development to particular urban problems;

c. Sponsorship of educational programs related to its other activities and to the general problem of using advanced technologies to improve urban life.

C. INITIAL POLICY DECISIONS

1. *Is transferability a high-priority problem?* Fundamental to the Conference and the work of the Continuing Committee is the assumption that high priority should be given to efforts to foster the transfer of advanced technologies to applications in urban areas. Such efforts involve the allocation of scarce human, organizational, and physical resources. This assumption should therefore not be made lightly, without some test of its validity. No shortcut or direct method of testing this assumption is apparent; its validation must involve experiment and experience. Although the Committee may not choose to undertake experimental validation itself, it should remain aware of experimentation undertaken elsewhere and should regularly review the implications of its own experience for the validity of this assumption.

2. *In the attempt to foster transferability, should particular emphasis be placed on space science?* Closely related to the preceding question is the proposition that the effort to foster the application of space technology as such to urban problems deserves high priority. The Committee should carefully consider the advantages and disadvantages of approaching the transferability problem in this more limited context. Economies of scale in such matters as the dissemination of scientific and technical information, and the self-evident value of having the widest possible range of scientific and technical capacity to draw upon, may well dictate a more general approach. On the other hand, the magnitude and frontier nature of the space efforts, and the benefits to be gained by drawing on the results of NASA's varied efforts to discover alternative uses for the results of space research and development, may argue for a narrower focus, initially at least.

3. *What is the appropriate allocation of effort between the two methods of approaching the transferability problem?* Identifying the most effective general approach to the transferability problem is another basic concern. One approach suggested at several points during the Conference is that the effort

should begin with the identification and analysis of critical urban problems. Available scientific and technical information and functional capacities should then be assessed to determine their usefulness in dealing with these problems. The alternative approach, also suggested, calls for focusing first on recent scientific and technical advances and moving from there to the identification of possible applications in the urban community. Although these two approaches are not mutually exclusive, the Committee will need to consider their relative merit in allocating its efforts between them.

4. *What is the Committee's proper role in relation to other activities fostering urban development in the Bay Area and in the Nation?* The concern of the Continuing Committee with efforts to employ advanced technologies in meeting the needs of urban communities places its work in the general context of urban development. It should therefore consider its relationships with other public and private research and action organizations having similar concerns. In order to maximize its contribution and avoid needless effort, the Committee should carefully identify the unique contributions it can make. In seeking to bring advanced technologies to bear more effectively on urban problems, the Committee should take advantage of programs of other groups.

Because the Committee is centered in the Bay Area, it must also determine the extent to which it should seek formal relationships with such regional urban groups as the Bay Area Council and the Association of Bay Area Governments. Such alliances could conceivably strengthen all of the groups and facilitate the Committee's efforts to undertake particular study and action programs.

In this context, the Committee must consider possible organizational and financial arrangements whereby it might undertake more specific activities related to its primary mission. It must determine the extent to which it will function as a whole, or through subcommittees possibly involving other area leaders. It must decide whether it will undertake major activities in its own right, or work principally as a catalyst encouraging other organizations to embark on specific projects. It must identify potential sources of financial support and develop mechanisms for relating this support to particular activities.

D. PROGRAM OPPORTUNITIES

1. Studies

On the assumption that the Committee chooses to help sponsor specific studies, these are some of the possibilities identified in the Conference:

a. *Identification of specific technological solutions.* One unique characteristic of this Conference was its stress on the identification of technological solutions to urban problems. As a number of participants pointed out, many problems of urban life require thought and action of a nontechnical nature. There may nevertheless be, as the Conference suggested, many significant and neglected technical opportunities. The Conference pointed up the importance of searching out those aspects of problems potentially susceptible to technological resolution and of systematically developing techniques for dealing with them.

The Continuing Committee could explore these possibilities by sponsoring studies directed to the identification of specific technological advances critical in the alleviation of urban difficulties. These studies should include not only those problems in which technology is assumed to be vital (such as air and water pollution), but also those not normally considered technological in nature (such as problems of racial minorities and of the aged). Studies of this nature are likely to profit from multidisciplinary analysis; small working conferences of experts from various fields at Dunsmuir House may therefore contribute to their progress.

A potentially fruitful variation on this approach would be the sponsorship of studies on the relative advantages of alternative technological solutions to the same problem. For instance, if a "package sewage treatment plant" for the individual household could be developed, would it be preferable to further refinement of general community sewage collection and treatment systems?

b. *Approaches to integrated solutions.* In many Conference discussions, references were made to the importance of approaching urban problems in the context of the total ecology of urban areas. This seems especially important in programs using advanced technologies and requiring substantial investment of scarce resources and producing widespread secondary effects. Many advanced technologies are economically feasible only when introduced over a large geographical area or a large range of activities. To understand what is being changed is desirable before introducing any social or technological innovation.

The foregoing considerations argue for the analysis of the total urban system. The systems engineering approach appears to hold promise as a means for meeting this need. Although it has been employed in the analysis and resolution of urban problems in specific instances, it has not had general applications. No thorough analysis yet exists of the peculiar problems associated with the application of systems engineering to urban problems. Sound use of new technologies in urban areas may require additional attention to refinement of this facilitative technique.

The Continuing Committee might contribute to this end by convening at Dunsmuir House a small working conference of experts on systems engineering and experts on urban problems. Basing its deliberations on carefully prepared background papers, this conference should try to assess what contributions systems engineering can make and to identify aspects requiring further study. Such a conference can produce a set of recommendations for research and experimentation. Some of these the Continuing Committee might then choose to pursue. These recommendations, together with the background papers and a summary of conference discussions, might also make a worthwhile publication.

c. *Diversification of Bay Area capabilities.* The Conference underscored the fact that space-related industries have a key role in the Bay Area economy. Future economic growth depends on the effective utilization of the functional capacities associated with these industries, not only to meet the demands of the space program, but for other purposes as well. The possibility of deliberate efforts to achieve greater geographical dispersion of Government contracting for space activities adds urgency to this consideration. Diversification is essential to insure long-term economic well-being.

In the context of its general concern with the welfare of the Bay Area, the Continuing Committee could appropriately turn its attention to the problem of diversification, and seek to investigate, on a regional basis, ways to enhance this diversification. Another possibility is a study of various methods for disseminating scientific and technical information as to their effectiveness in encouraging diversification. For example, it would be useful to understand better the general pattern of communication of this kind of information in the local industrial community, and to relate the effectiveness of local or regional programs, as against national programs, to improve the communication process and its content.

d. *Goals and values in urban innovation.* Another subject arising often during the Conference is the matter of goals and values in urban life. For technology to yield a better urban life, some knowledge of what would constitute a better life is clearly necessary. If humane purposes are to guide technological development, these purposes need to be known.

No final settlement of these questions is ever likely; but the opportunities and hazards attendant upon the use of modern technology make it important to be as precise as possible about them. The responsibility for deliberating and making judgments about such matters resides ultimately with the community's citizens, and it is to them that we must eventually turn. However, because citizens may not have these judgments consciously in mind or clearly formulated, special efforts may be necessary to discover what their present judgments are and encourage and contribute to further thought about them.

The Continuing Committee might undertake studies of what the citizens of the Bay Area actually want in their cities, and of means whereby they can participate more actively and effectively in the continuing process of identifying and refining community goals. Such an undertaking might contribute significantly to the Committee's efforts to set priorities for research and experimentation in the application of advanced technologies to urban problems.

2. Experimental and Demonstration Programs

The Conference record refers to a number of specific possibilities for the application of the results of space research and development to urban problems. References to these possibilities appear in the Analytical and Subject Index (appendix D). The Continuing Committee might choose from among these possibilities in undertaking experimental or demonstration projects.

The Conference did not provide occasion for close analysis of these possibilities. Many appear only as illustrations in the context of general expositions on the importance and profitability of seeking out opportunities for technological transfer. The Committee should therefore proceed cautiously in pursuing any particular project, first thoroughly analyzing its feasibility.

Before undertaking any experimental or demonstration project, the Committee should investigate the extent to which the technology in question is in operational use. For example, at least one California city keeps all of its operational records, from police arrests to school grades, in computer storage. The experience of this city, or of others with even more completely automated record storage and retrieval, might meet the need for experiment or demonstration of the advantages and disadvantages of using computers for urban recordkeeping.

The Committee may be able to work with other groups carrying on pilot or demonstration projects. Several homemaking magazines, for example, periodically sponsor demonstration homes. They might cooperate with the Committee in making one such home a demonstration of the application of space technology to the building industry.

In some instances, the Committee may be able to catalyze sponsorship of pilot or demonstration projects by other groups. Technical societies or industrial associations might sponsor, for example, a pilot suburb involving such novelties as underground vehicular traffic, integrated closed-circuit communication, broadcasting, and meter reading, and application of space-age technologies to water and air purification and sewage waste disposal. Such a pilot suburb might well be part of some future "World's Fair."

3. Educational Programs

General open conferences of the size and style of the Dunsmuir Conference are of strategic value in focusing attention and galvanizing action. The Dunsmuir Conference itself had this value, among others. However, the Continuing Committee should not assume that general open conferences are always a good thing. Too many can vitiate their strategic value for turning stalemate into progress at a critical point. Before recommending any such general open conference, therefore, the Continuing Committee will do well to assess with care its probable benefits.

Small informal working conferences among experts have quite a different value. The preceding paragraphs contain several specific suggestions for such conferences. Where solution of problems involves collaboration in two or more technical fields, and particularly where these fields have few existing direct channels of intercommunication, such a conference can serve both as a means of approach to solution of specific problems and as a means of developing channels and language for further intercommunication. The criteria for the format of such a conference include:

(a) That it be small, involving no more people (say 25) than can comfortably participate in a single discussion;

(b) That it be closed, involving only experts individually selected for their competence in dealing with the problem under discussion;

(c) That it be informal, rather than giving the participants the feeling that they are speaking for publication;

(d) That it be working, directed toward solution of problems delineated specifically and concretely beforehand.

In this as well as in other aspects of the Committee's action on its agenda, it will do well before calling even such working conferences, to make sure that someone else is not doing or could not do substantially the same task. Resource papers, embodying results of prior study in individual disciplinary areas, can expedite the work of such a conference.

In addition to conferences, the Continuing Committee may consider other approaches to diffusion of information about application of technology to urban problems. Under its sponsorship, for example, Dunsmuir House might serve either as an information center on space, science, and urban life, or as a "display case" for popular presentation of the possibilities for technological innovation in urban life. The advisability of any of these approaches depends on the policy decisions which the Committee must initially make and continually review.

APPENDIX D

ANALYTICAL AND SUBJECT INDEX

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